REPORT #
RRTAC 89-4

Manual of Plant Species Suitability for Reclamation in Alberta -- 2nd Edition

Recreation, Parks and
Wildlife Foundation

Heritage Fund

Alberta
LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

Alberta's Reclamation Research Program

Regulating surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from Alberta Environment and two Deputy Chairmen from Alberta Forestry, Lands and Wildlife. The Council oversees a reclamation research program, established in 1978, to identify the most efficient methods for achieving acceptable reclamation in the province. Funding for the research program is provided by Alberta's Heritage Savings Trust Fund, Land Reclamation Program.

To assist with the development and administration of the research program, the Council appointed the inter-departmental Reclamation Research Technical Advisory Committee (RRTAC). The Committee consists of eight members representing the Alberta Departments of Agriculture, Energy, Forestry, Lands and Wildlife, and Environment, and the Alberta Research Council. The Committee updates research priorities, reviews research proposals, organizes workshops, and otherwise acts as the coordinating body for reclamation research in Alberta.

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REPORT #
RRTAC 89-4

MANUAL OF PLANT SPECIES
SUITABILITY FOR RECLAMATION
IN ALBERTA
-- 2ND EDITION

by

Hardy BBT Limited

Prepared for

ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL
(Reclamation Research Technical Advisory Committee)

1989

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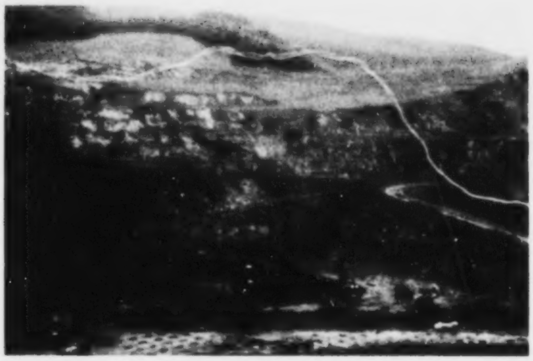
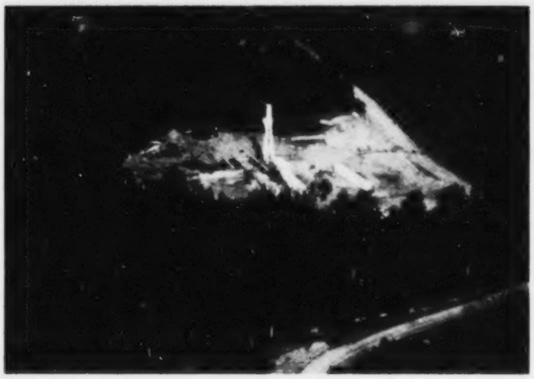
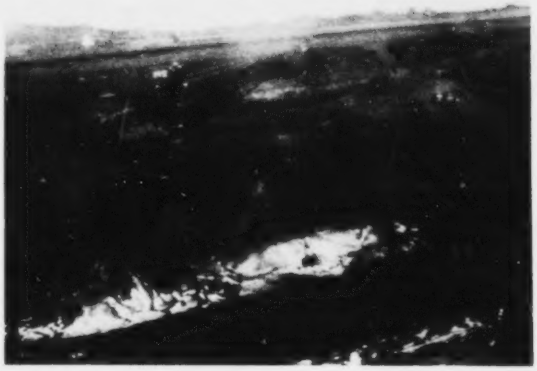
Reclamation Research Technical Advisory Committee







Mission: To coordinate and foster reclamation research in Alberta.

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DISCLAIMER

This report is intended to provide government and industry staff with up-to-date technical information to assist in the preparation and review of Development and Reclamation Approvals, and development of guidelines and operating procedures. This report is also available to the public so that interested individuals similarly have access to the most current information on land reclamation topics.

The opinions, findings, conclusions, and recommendations expressed in this report are those of the author(s) and do not necessarily reflect the views of government or industry. Mention of trade names or commercial products does not constitute endorsement, or recommendation for use, by government or industry.

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INTRODUCTION

In 1980 RRTAC published RRTAC Report No. 80-5: Manual of Plant Species Suitability for Reclamation in Alberta to provide users with information on a variety of plant species suitable for use in reclamation programs in Alberta. The manual was well received and went out of print in late 1988. An "updated" manual was prepared in 1989. The "update" added new information on the species in the manual which had become available through operational and research activities, primarily in Alberta. Performance data on new varieties tested in Alberta and new species (Pinus banksiana and Agropyron dasystachyum) were also added to the manual. With the addition of the new species the manual includes information on forty-four grasses, fourteen forbs and thirty-five trees and shrubs.

The objectives of the "update" were:

1. to reprint original information in RRTAC Report 80-5: Manual of Plant Species Suitability for Reclamation in Alberta, and
2. to add new information to the manual.

Prior to reprinting, the species information was reorganized under several major headings: Species Biology, Species Tolerances and Reclamation Considerations. In order to further improve the accessibility of the information contained in the manual, a summary page with a suitability map was prepared for each species. The summary, presented in tabular form, provides, for key reclamation parameters, a rating of the performance of each species. A Species Suitability Map for each species identifies the ecoregion(s) of Alberta where the species is best suited, based upon information from field test results and natural occurrence of the species in Alberta.

A Combined Performance Chart was also prepared for each of the grass, forb and tree/shrub groups, rating each species for selected key reclamation parameters.

Reclamation Planning

Effective reclamation of disturbed lands is very much dependent on good planning. The main constituents of a reclamation plan are:

- description of existing site conditions
- choice of final land use
- establishment of final landform
- water management and erosion control
- soil reconstruction, and
- revegetation

Detailed information on the existing site conditions is an important component of reclamation planning. This baseline information includes data on slopes, elevations, aspects, drainage patterns, vegetation and soil conditions. Soils information can be used to determine the need for amendment or to select soils suitable for salvage. Description of vegetation provides information on plant species adapted to local climatic and soil conditions. An examination of species colonizing nearby disturbed areas is also beneficial as this is valuable in understanding natural plant succession. This will also provide information on local sources of plant materials for use in revegetation.

The choice of final land use should be determined at an early stage in the planning process, so that the economics and practicality of various reclamation options can be assessed. The appropriate land use should be chosen after discussion between the landowner(s), developer and various regulatory agencies.

The post-development landform should be compatible with the post-development land use objective and drainage regime. A critical feature of reclamation planning is to prevent erosion of the disturbed area, and to protect off-site water quality conditions.

A prerequisite to successful reclamation is the preparation of a suitable soil for plant growth. Where soil conditions are marginal because of some adverse physical or chemical properties, the chance of successful reclamation will be greatly enhanced by ameliorating these properties to acceptable levels for plant growth, especially if climatic conditions are extreme.

The revegetation phase of reclamation should be viewed as a land management process, rather than a "one-time" task. It involves obtaining suitable seed, determination of plant nutrient requirements, propagation of plant material, planting (often in stages), monitoring success and on-going maintenance.

This plant species manual has been prepared to aid in selection of plant species suitable for reclamation in Alberta. It is designed to enable the user to select appropriate plant species that are adapted to specific site conditions. Where sites to be reclaimed are extensive, variability between microsites should be considered. Differences in microsite characteristics may result in a decision to plant different species in different locations within the disturbance site.

HOW TO USE THE MANUAL

To select appropriate species using this manual, the following procedure should be followed:

1. Refer to the combined performance chart at the head of each section dealing with grasses, forbs, trees and shrubs.

2. Next, use the Species Suitability Map to determine if the species is adapted to growing in your area of interest.

3. Refer to the Summary Table which provides information on individual species tolerances and preferences. Use this information to refine your choice to those species most adapted to the site conditions.

4. Finally, review the species description to confirm final species selection.

Combined Performance Chart

The combined performance chart at the head of each major section rates the preference of each species according to a number of key parameters critical to reclamation success, i.e., cold tolerance, drought tolerance, pH tolerance, salt tolerance, textural preference. Using this chart a number of potentially suitable species may be identified.

The next step is to turn to each of these species within the manual. The summary page for each species, always situated at the beginning of each new species and on the left hand page, provides a map showing the region in Alberta where the species is expected to do best. It may also grow elsewhere, but it is likely that other available species will perform better in those areas.

Species Suitability Maps

The ecoregion map of Alberta, as developed by Strong and Leggat (1981), was used as the basis for delineating regions within Alberta which are most suitable for the reclamation species. These are described in the section "Species Suitability Regions." The basic assumption in using this approach is that a revegetation species tested on a typical site within an ecoregion will most likely be adapted to the normal range of sites within that entire ecoregion. The recommended area for a given species corresponds to the ecoregion where there is a good probability of success on the normal range of sites. The conditional area refers to ecoregions where the species may be expected to perform well but it has not been tested in the ecoregion, or it may perform well on particular sites or with special management.

Strong and Leggat recognized twelve ecoregions with distinctive climatic conditions and vegetation. For the purpose of this manual some of these ecoregions have been combined into one. The reasons for this are several: in some cases performance data of the revegetation species are not precise enough to distinguish between ecoregions or, as in the case of the Cordilleran ecoregion, it was impossible to indicate on the small map whether the species was suited to alpine, subalpine or montane. In this case, if a species is adapted to any one of these three ecoregions, the entire Cordilleran ecoregion will be shaded. Adaptability of the species to this diverse region can be determined from the Summary Table below the species suitability map. A species with very high winter hardiness would be adapted to alpine ecoregions, a high winter hardiness would indicate adaptation to the subalpine ecoregion but not the alpine, and a moderate rating would indicate that the species is adapted to the montane, but not the alpine or subalpine regions. It should be noted that Canada Parks Service has strict rules regarding plant species that may be used within National Park boundaries. These rules should be checked as part of the species selection process.

Summary Table

The Summary Table includes the information in the combined performance chart plus information on several other key tolerances and preferences. Tolerances and preferences summarized in this table are based on information contained in the species descriptions. When different tolerances are reported, they are given as a range. Where a particular value (eg. pH) has been reported, this value is included in the Summary Table. Some species may be eliminated after considering the summary information. For those species still in the running, the information contained within the Manual should be considered carefully to be assured that the species is adapted to the site and will provide the desired plant cover.

Species Information

Information about the species covers a wide range of topics. This is presented in a quantitative form where such information is available. It is also presented in a qualitative form as described in the original reference or where a rating could be inferred from habitat observations. Various adjectives used in the literature have been converted to standardized ratings summarized in the combined performance charts. Examples of these adjectives (with the standardized version in brackets) are given below:

> moderate (medium), extremely (very high or none), good (medium), very good (high), best (very high), tolerant (high), very tolerant (very high), excellent (high), relatively (medium), some (medium), long-lived (very high), poor (low), fair (low), mildly (low), strongly (high), performed well (high), heavy grazing (high).

In general, if equally reliable information sources provided contradictory data on the tolerances, preferences or characteristics of a species, the divergent facts were presented. In some cases, recommendations or data from the literature were very case or site specific These were not presented if it was considered to be misleading to the user.

In describing the taxonomy of each species the nomenclature of Moss (1983) has been adopted. Where a species was not contained in Moss (1983), the reference has been cited.

An important feature of this Manual is that all sources of information have been cited. Identifying numbers for references from which information was drawn have been provided following each statement. **Where the user finds unreferenced statements, information has been supplied by the authors based on their observations, or professional judgements.** It was considered important to address every parameter unless the information required was highly specific and/or no indications whatsoever emerged.

Some of the parameters addressed in the species accounts are straightforward. Several, however, are variable in their detail and scope:

Ecological Setting - This parameter includes commonly associated species under natural conditions, habitat, preferred ecological zone, precipitation requirements, favored microsite conditions and elevational preferences (where these are known).

Soil Preferences - This describes not only moisture (drainage) and textural considerations, but soil orders of common occurrence, preferred soil depth, optimum slope and exposure, and known success under specific artificial soil conditions.

Seed or Planting Stock Availability - Included here is not only commercial availability of seed, but details of licensing and experimental cultivars.

Methods and Ease of Establishment - This covers a wide range of topics associated with seeding and transplanting methods and success, including fertilizer and equipment requirements, ease of establishment, germination, early survival, seed purity and viability, and seasonality of collections, storage, seed preparation and planting. Reliable details were not available in all cases. It should be kept in mind that adapted ecotypes are usually preferable. Selection of the proper commercial cultivar should also be carefully considered (Lowen and Walker 1989). In many cases, seed merchants or seed catalogues are very helpful. **Where seeding rates and dates have been given it must be kept in mind that these are only for general reference - the reader should always evaluate local conditions and requirements before selecting a seeding rate and time.**

Current Status for Reclamation - This is the broadest of all the sections. It includes experimental and operational experiences in Alberta through 1988, elsewhere in Canada, and in the United States. It attempts to cover the recommended types of industrial and agricultural uses and, if not in use, where promising situations exist. Usually, a brief summation of the species' chief advantages and disadvantages for reclamation under Alberta conditions is also provided.

Should the manual not provide the level of information or the detail required, references in the bibliography should be consulted.

Example of How to Select Plant Species for a Particular Site

An example is given here to illustrate use of the Plant Species Manual for determining a list of appropriate plant species. Assume that there is a site disturbed by pipeline construction near Lethbridge. The soils have a loam to sandy loam texture and are moderately saline (electrical conductivity values range from 6 to 10 mS/cm). The site is well to moderately well drained with moderate (10 to 15%) slopes and is presently used for grazing cattle. Plant species (grasses and legumes) suitable for use will therefore need to have the following attributes: drought tolerance, salt tolerance, palatability, persistence and capability for providing an erosion controlling cover.

STEP 1

Refer to the Combined Performance Charts for grasses and forbs (Tables 2 and 3) to obtain a list of potentially suitable species. Those species with ratings of medium or better for each of the desired attributes are considered suitable. These include:

Agropyron dasystachyum
Agropyron intermedium
Agropyron smithii
Agropyron trachycaulum
Agropyron trichophorum
Bromus inermis
Elymus junceus
Festuca arundinacea
Festuca rubra
Oryzopsis hymenoides
Poa compressa
Pucinella distans
Lotus corniculatus
Medicago spp.

STEP 2

Refer to Figure 1 and to the Species Suitability Maps for each species to determine if each species is adapted to growing in the appropriate Species Suitability Region (2). Eliminate those species that are not recommended for this Species Suitability Region. In this example Lotus corniculatus was eliminated.

STEP 3

Refer to the Summary Table (below the Species Suitability Map) which provides further information on individual species tolerances and preferences. Features which are considered here are soil moisture preferences (moist to dry), soil texture preferences (medium to coarse textured), browse tolerance, and availability of seed. The resulting list of species now includes:

Agropyron dasystachyum
Agropyron intermedium
Agropyron trachycaulum
Agropyron trichophorum
Bromus inermis
Elymus junceus
Oryzopsis hymenoides
Poa compressa
Medicago spp.

STEP 4

Review the species descriptions to confirm final species selection. Features which can be considered include nutrient requirements, susceptibility to disease and insect damage, soil building capability, competitive ability and methods and ease of establishment. Bromus inermis was eliminated because of its tendency to dominate other grasses in a mixture. Agropyron trachycaulum and Oryzopsis hymenoides were eliminated because they do best on moist sites. The final list of species includes:

Agropyron dasystachyum
Agropyron intermedium
Agropyron trichophorum
Elymus junceus
Poa compressa
Medicago spp.

These species are well adapted to the climatic conditions of the area, and will provide an erosion controlling cover that is self-sustaining. They are also salt tolerant and will also produce a high yielding pasture.

Information on availability of appropriate commercial cultivars and assistance with formulation of the seed mix can be obtained form local seed merchants.

SPECIES SUITABILITY REGIONS

The seven regions of species suitability are described in Table 1 and their distribution is shown on Figure 1. The twelve ecoregions recognized by Strong and Leggat (1981) have been maintained and where several ecoregions have been combined, a range of vegetation, soil and climatic conditions are indicated.

Species Suitability Region 1

This corresponds to the Short Grass Ecoregion (Table 1) and is located in the southeastern corner of Alberta. The Short Grass Ecoregion has the lowest mean summer precipitation (210 mm) of any ecoregion in Alberta. The mean yearly precipitation is 340 mm with a range of 260 to 380 mm. The mean May to September temperature is 15.0° C with a range from 14.5° to 16.0° C. The warmest month is July with a mean temperature of 18.5° C and a range of 17.5 to 20.0° C, the warmest summer conditions of any ecoregion in the province.

The high summer temperatures, low precipitation, strong winds, and high insolation combine to produce high potential evapotranspiration values and a large climatic moisture deficit (260 to 350 mm). This moisture deficit is a severe limiting factor for many plants.

Snow depths are shallow with relatively few days with continuous snow cover. This ecoregion has the lowest mean October to April precipitation. The cold mean winter (December to February) temperatures (-10.5° C) coupled with shallow snow cover lead to very harsh winter conditions for vegetation.

The southwest corner of this ecoregion receives an average of 35 chinook days per year, but the remaining area receives 10 to 20 chinook days. (A chinook day is defined as one with the daily maximum temperature above 4° C from December to February).

The plant species of this ecoregion reflect the severe deficit that occurs during mid to late summer. Grama grass is the dominant species with significant amounts of spear grass. During wetter periods of climatic cycles, spear grass increases in cover. Modal soils within this ecoregion are medium textured, well to moderately well drained Brown Chernozems.

Species Suitability Region 2

This corresponds to the Mixed Grass Ecoregion which is situated adjacent to the Short Grass Ecoregion. The Mixed Grass Ecoregion receives between 200 and 290 mm of precipitation during the May to September period. This is approximately 50 mm higher than for the Short Grass Ecoregion. The slightly lower summer temperatures (range 13.5 to 15.0° C) result in lower potential evapotranspiration. The climatic moisture deficit in the Mixed Grass Ecoregion ranges from 200 to 300 mm with a mean of 240 mm; 60 mm less than for the Short Grass Ecoregion.

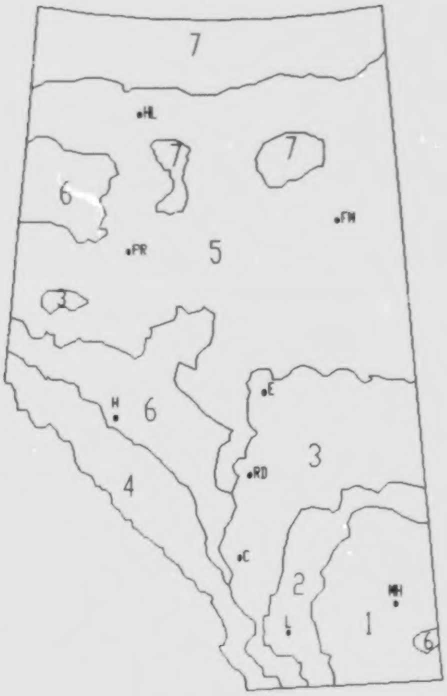
In comparison with the Short Grass, the Mixed Grass Ecoregion has similar winter temperatures, a deeper snow cover, and the snow remains on the ground longer, however these differences are small. The southern portions of this ecoregion receive about 30 chinook days per year, while the northern portions receive less than 10 chinook days.

The modal vegetation is dominated by spear grass with secondary quantities of grama grass and wheat grass. Shrubs (buck brush and wolf willow) and trees (aspen) occur where moisture is locally available throughout most of the growing season. Mixed Grass sites that are drier than the modal conditions have vegetation more typical of the Short Grass Ecoregion. Modal soils in this ecoregion are moderately well drained Dark Brown Chernozemic soils.

Species Suitability Region 3

This Species Suitability Region comprises two ecoregions: The Fescue Grass and Aspen Parkland Ecoregions. The Fescue Grass Ecoregion lies west of the Mixed Grass Ecoregion and is the smallest grassland ecoregion. The Aspen Parkland Ecoregion is located north of the Mixed Grass and west of the Fescue Grass Ecoregions. The Aspen Parkland and Fescue Grassland receive nearly equal amounts of summer precipitation; however, precipitation occurs early in the summer within the Fescue Grassland which produces a significant late summer moisture deficit.

Mean yearly precipitation in the Aspen Parkland is 450 mm, 50 mm more than the Mixed Grass Ecoregion. Mean annual precipitation ranges from 390 mm at Camrose to 720 mm at Mountain View-Birdseye, a zone of high precipitation restricted to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1. Short Grass
2. Mixed Grass
3. Aspen Parkland - Fescue
4. Subalpine - Montane - Alpine
5. Boreal Mixedwood
6. Boreal Foothills - Uplands
7. Boreal Northlands - Subarctic

Figure 1. Species Suitability Regions

Table 1 Plant species suitability regions[a]

Species Suitability Region	Ecoregion	Dominant Vegetation	Dominant Soil	Dominant Climatic Regime	Mean May to September				Total Annual Precipitation (mm) (Min-Max)
					Temperature (C)	Frost Free Period (Days)	Precipitation (mm) (Min-Max)	Month of Maximum Precipitation	
1	Short Grass	Grama-Spear Grass	Brown Chernozem	Prairie	15.0	115	170 to 250	June	260 to 380
2	Mixed Grass	Spear-Grama-Wheat Grass	Dark Brown Chernozem	Prairie	14.5	110	200 to 290	June	300 to 470
3	Fescue Grass	Rough Fescue-Parry Oatgrass	Black Chernozem	Prairie-Cordilleran	12.5	90	230 to 370	June	370 to 570
	Aspen Parkland	Aspen and Rough Fescue Grassland	Dark Gray and Black Chernozem	Prairie-Boreal	13.0	95	250 to 400	July	390 to 710
4	Montane	Douglas Fir	Eutric Brunisol	Cordilleran-Prairie	11.5	75	110 to 390	June	280 to 810
	Subalpine	Lodgepole Pine (Secondary Succession by Engelmann Spruce)	Eutric Brunisol	Cordilleran	9.5	15	180 to 430	June	350 to 1230
	Alpine	Phyllodoce	Brunisol	Cordilleran-Arctic	6.5	–	270 to 430	June	570 to 970
5	Boreal Mixedwood	Aspen-Poplar	Gray Luvisol	Boreal	12.0	85	200 to 440	July	360 to 520
6	Boreal Foothills	Aspen-Poplar-Lodgepole Pine (Secondary Succession by White and Black Spruce)	Gray Luvisol	Boreal-Cordilleran	11.5	80	230 to 450	July	510 to 670
	Boreal Uplands	Lodgepole Pine (Secondary Succession by White and Black Spruce)	Gray Luvisol	Boreal-Cordilleran	10.0	75	220 to 470	July	440 to 740
7	Boreal Northlands	Aspen-White Spruce	Gray Luvisol	Boreal-Arctic	11.0	85	180 to 340	July	300 to 450
	Boreal Subarctic	Black Spruce/Sphagnum	Organic Cryosol	Boreal-Arctic	10.0	–	——	July	——

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[a] Adapted from Strong and Leggat (1981).

the foothills. Although the range of mean May to September temperatures in the Aspen Parkland is greater than in the Fescue Grassland, the mean values for the two regions are similar.

The Aspen Parkland was delineated on the basis of co-existent Chernozemic soils (Black and Dark Brown) and aspen/grassland vegetation. Black Chernozems are the common soils within the Fescue Grassland. They have been refered to as "shallow" (less than 30 cm) Black Chernozems as opposed to "deep" Black Chernozems which are characteristic of the Aspen Parkland.

Dominant vegetation in the Fescue Grassland is rough fescue with secondary quantities of Parry oat grass. Shrub communities become increasingly important as moisture increases. The Aspen Parkland is a transition zone between boreal forest and prairie grasslands. Plant cover varies from clumps of aspen comprising 15% cover within fescue grassland and shrub communities, to extensive stands of aspen with patches of grassland.

Species Suitability Region 4

This Species Suitability Region comprises three ecoregions: the Montane Ecoregion, Subalpine Ecoregion and the Alpine Ecoregion. The Montane Ecoregion is restricted to the foothills and major valleys of the Rocky Mountains. The main occurrances are in the vicinity of the Porcupine Hills, Crowsnest Pass and foothills north of Waterton Lakes National Park. The Bow, Saskatchewan and Athabasca River Valleys also contain Montane Vegetation.

Ecological conditions are highly variable, however the Montane has the warmest December to February temperature (mean of -7.5° C) of any ecoregion in Alberta. The Montane Ecoregion is distinguished by open stands of Douglas fir on shallow, moderately well drained Eutric Brunisols. In cooler areas, the Douglas fir occupies sites which have well drained soils and/or steep south aspects where solar insolation is increased. Limber pine is largely confined to rapidly drained sandstone outcrops. Grasslands may also be found on steep south-facing slopes or coarse textured soils.

The Subalpine Ecoregion is an altitudinal vegetation zone with the upper boundary formed by the Alpine Ecoregion and the lower boundary abutting the Montane, Aspen Parkland and the Boreal Uplands Ecoregions. It occurs from 1520 to 2135 m south of the Bow River, 1620 to 2135 m north of the Bow River, and 1490 to 1975 m in the vicinity of Grande Cache. This ecoregion is characterized by snowy cold winters and showery cool summers. Below freezing temperatures in the subalpine are common during all months with the lowest frequency during July and August. The lowest elevations of the Subalpine Ecoregion are characterized by lodgepole pine which shows little evidence of succession to Englemann spruce and/or alpine fir in the first 200 years of stand growth. Soils are typically shallow, poorly developed Eutric Brunisols. Higher elevation sites above the lodgepole pine zone are characterized by Engelmann spruce-alpine fir forests. Spruce is usually much more abundant. Soils are predominantly Eutric Brunisols. At the upper limit of the Subalpine Ecoregion, typical species are dwarfed Englemann spruce, alpine fir and whitebark pine, and open stands of alpine larch. Plant growth is restricted because of low temperatures, high wind, moisture stress, and the short growing season.

The Alpine Ecoregion occurs above the climatic forest-line in the Rocky Mountains. It is characterized by strong winds, long winters and summer coolness. Below freezing temperatures are common even during the warmest months. The Alpine Ecoregion is found above 2135 m in southern Alberta but declines to about 1980 m in the northern portions. The mean May to September precipitation is 360 mm which is 40 mm higher than in the Subalpine Ecoregion.

Plant communities within the Alpine Ecoregion are characterized by low-growing vegetation whose distribution is strongly influenced by snow cover. Red heather communities are commonly found on moderately well drained sites with white heather communities dominant on mesic to wet sites. Willow communities are found on imperfectly to poorly drained sites resulting from later summer snowmelt and alongside streams.

Species Suitability Region 5

This corresponds to the Boreal Mixedwood Ecoregion which comprises approximately 43% of the province. This ecoregion has a low energy climate with short winter days and long summer days. Despite the length of summer days, potential solar energy available at the ground surface is lower than ecoregions at lower latitudes. More than 70% of the total precipitation occurs during the summer with July being the wettest month. Mean annual precipitation is about 440 mm with a range of 350 to over 600 mm. The Boreal Mixedwood Ecoregion has the coldest mean winter temperature, and the largest range between the mean winter and summer temperatures of all the ecoregions. The mean

December to February temperature is -15.5° C with a range of -11.5 to -23.5° C. The mean frost free period is 85 days, 10 days shorter than for the Aspen Parkland.

The Boreal Mixedwood Ecoregion is primarily composed of deciduous forests dominated by trembling aspen with secondary amounts of balsam poplar. White spruce and balsam fir are the potential climax species on mesic sites. The understory vegetation is varied and includes such species as reed grass, wild rye, pea vine, vetch, roses, dogwood, willows and Saskatoon berry. Soils are predominantly Gray Luvisols.

Jack pine communities developed on sandy parent materials are also common within the Mixedwood Ecoregion. The largest concentration of this vegetation type lies south of Lake Athabasca. Blueberry, bearberry and lichens are major understory components. Soils are primarily Eutric and Dystric Brunsols.

Poorly drained sites within the Mixedwood Ecoregion support black spruce communities, with an understory of Labrador tea, cowberry and mosses.

Species Suitability Region 6

Species Suitability Region 6 comprises the Boreal Foothills Ecoregion and the Boreal Uplands Ecoregion. The Boreal Foothills Ecoregion lies on the west side of the Boreal Mixedwood Ecoregion and parallel to the Rocky Mountains from Turner Valley northward to the British Columbia border southwest of Grande Prairie. Outliers of this ecoregion occur in the Clear and Saddle Hills, Pelican Mountains, Pushwaskau Hills and Cypress Hills. The mean yearly precipitation is 570 mm with a range of 510 to 670 mm. Summer precipitation totals vary from 230 to 450 mm with the outliers receiving less than 300 mm. The mean May to September temperature in the Boreal Foothills is 11.5° C with a range of 10.0 to 12.5° C. Winter temperatures are relatively warm, the mean December to February temperature is 5.0° C higher than the Boreal Mixedwood Ecoregion.

This ecoregion is characterized by the codominance of aspen, balsam poplar and lodgepole pine. Paper birch, white spruce, black spruce and fir are also common associates on moderately well drained sites. Both white and black spruce can be successional and potential climax species on the same site. The mixture of species on a given site is dependent on site conditions, geographical location and fire history. In general the deciduous components dominate. The understory vegetation comprises Labrador tea, roses, wild rye, willows, fireweed and wintergreen. Modal soils are Gray Luvisols.

The Boreal Uplands Ecoregion occurs north of the Bow River to the Grande Cache area with outliers occurring in the Clear and Swan Hills. It is associated with both mountain and foothills. The mean annual precipitation is similar to the Boreal Foothills at 570 mm. Summer precipitation varies from 290 to 470 mm with a mean of 380 mm. The Boreal Uplands has cool summer temperatures with a mean of 10.0° C and a range of 8.5 to 11.5° C. Mean winter temperature (-10.0° C) is similar to the Boreal Foothills. Lodgepole pine is the prevalent tree species on moderately well drained sites with succession to white spruce, or black spruce on imperfectly drained sites. The understory is less diverse than the Boreal Foothills Ecoregion but includes such species as alder, wintergreen, aster, mosses, twinflower and wild rye. Soils are predominantly Brunisols and Luvisols. Organic and Gleysolic soils are found in poorly drained depressional areas dominated by black spruce.

Species Suitability Region 7

This region comprises the Boreal Northlands and Boreal Subarctic Ecoregions. The Boreal Northlands Ecoregion is found north of the Boreal Mixedwood with outliers at the upper elevations of the Buffalo Head Hills and Birch Mountains. Mean annual precipitation ranges from 300 to 450 mm. Mean summer temperature is 11.0° C, and the mean frost free period is approximately 85 days. The mean length of snow cover is 185 days, which is much longer than for any ecoregion except parts of the Subalpine and Alpine.

Mixed aspen and white spruce forests dominate well drained sites within the Boreal Northlands Ecoregion. This ecoregion is distinguished from the adjacent Boreal Mixedwood Ecoregion by the increased abundance of white spruce. Understory species include buffaloberry, wild rose, cowberry, willows, fireweed, blueberry, wild rye, twinflower and mosses. Jackpine stands dominate rapidly to well drained sites. Imperfectly drained sites are dominated by white spruce with secondary quantities of black spruce, while black spruce dominates poorly drained sites.

Luvisolic soils are typical on moderately well drained sites with Dystric Brunisols on well to rapidly drained sites. Gleysolic and Organic soils are found on the imperfectly to poorly drained sites.

The Boreal Subarctic Ecoregion is limited in extent and is composed of the Cameron Hills, Caribou Mountains and Buffalo Head Hills of northern Alberta. It has wet summers with low energy input which does not allow the soil to warm above freezing. This ecoregion is characterized by the presence of discontinuous permafrost and a sparse forest cover. Open black spruce stands developed on Organic Cryosols are typical with an understory of sphagnum mosses, cloudberry and lichens. Poorly drained sites lack tree cover but have similar ground vegetation.

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SPECIES INFORMATION - GRASSES

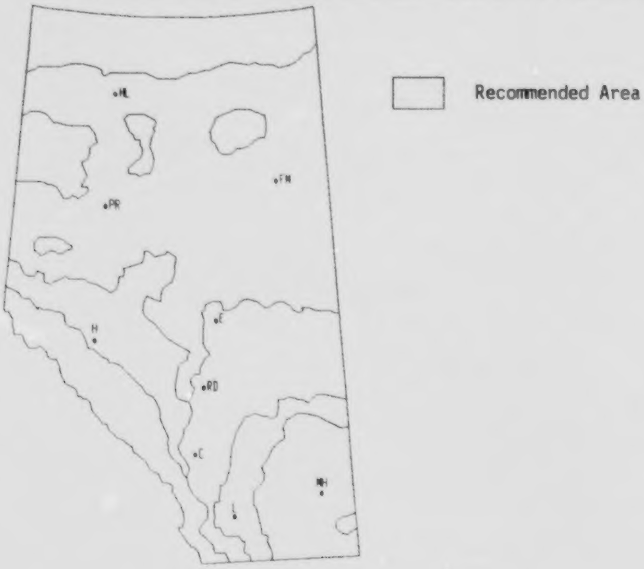
Table 2 Combined performance chart - grasses

Species	Reclamation Suitability Criteria							
	Drought Tolerance	Salt Tolerance	Winter Hardiness	Soil Reaction Tolerance		Erosion Control	Persistence	Palatability
				Acid	Base			
Agropyron dasystachyum	VH	M	M	M	H	H	VH	M
Agropyron elongatum	H	VH	M	U	VH-H	M	VH	M-L
Agropyron intermedium	M	M	M	L	M-L	H	H	H
Agropyron pectiniforme	H	M-L	VH	U	M	VH-H	VH	H
Agropyron riparium	H	M	H-M	M	M	VH-H	VH	L
Agropyron smithii	H-M	H-M	M	M	M	H	VH	H-M
Agropyron spicatum	H	L	M-L	L	M	VH	H	H
Agropyron subsecundum	H-M	M-L	H-M	L	M	H	M	H-M
Agropyron trachycaulum	M	H-M	H	U	H	H	M	M
Agropyron trichophorum	H-M	M	M	M-L	M	H	H-M	M
Agrostis alba	M-L	L	H-M	H	L	M	H	M-L
Agrostis scabra	M	L	VH	H	U	H	L	M
Alopecurus arundinaceus	M-L	L	VH-H	H	L	H	VH	H-M
Arctagrostis latifolia	L	L	VH	VH	U	H	M	M
Bromus inermis	H-M	M	H-M	M	M	H-M	VH-H	VH-H
Bromus marginatus	M	L	H	L	M	H	M	H
Calamagrostis canadensis	H	M	VH	VH	U	M	VH-H	M-L
Calamagrostis purpurasecens	M	L	H	U	M	H-M	M	L
Calamovilfa longifolia	H	N	M	L	M	H	M	M-L
Carex atherodes	M	L	M	L	M	H	H	M
Carex rossii	VH	L	H	M	L	H-M	H	H-M
Dactylis glomerata	M	L	H-M	M	L	M	VH-H	H
Deschampsia caespitosa	M-L	M-L	VH	H	M	H-M	M	M-L
Distichlis stricta	M	VH	M	U	H	VH	H	L
Elymus innovatus	L	L	H-M	L	L	H-M	M	H-L
Elymus junceus	H-M	H	M	L	M	M	H	VH-H
Festuca arundinacea	M	H	M	H	M	H	H	H-L
Festuca ovina	H-M	L	VH	M	L	H	H	H-L
Festuca rubra	H-M	H-M	VH-H	H	M	H	H	VH
Hierochloe alpina	M-L	M	VH	L	L	H	M	L
Hordeum jubatum	M	VH	H	N	M	H	H	M-L
Koeleria macrantha	H-M	L	H	L	M	M	H	H
Lolium perenne	L	M	H	H	L	M	L	H
Muhlenbergia asperifolia	L	H	M	U	H	H	H	M-L
Oryzopsis hymeroides	VH-H	M	H	L	M	H-M	M	H
Phalaris arundinacea	M-L	H-L	M	H-M	M	H	VH	M-L
Phleum alpinum	H	M	VH	M	M	M-L	M	H
Phleum pratense	L	L	M	VH	L	M	H-M	H
Poa alpina	M	L	VH	H	U	M	H	H
Poa compressa	H-M	M	H	H	M	H	H	H
Poa pratensis	M-L	L	VH-H	M	M	VH	H	H-M
Pucinellia distans	M	VH-H	M	L	H	H	M	M
Stipa viridula	M	L	M	U	M	M	M	H-M
Trisetum spicatum	VH-M	L	VH	M	M	M	H	H

VH - very high
H - high
M - medium
L - low
N - none
U - unknown

Agropyron dasystachyum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance	X	X			
Salt Tolerance			X		
pH Acid			6.0		
Tolerance Base		9.5			
Winter Hardiness			X		
Erosion Control		X			
Persistence	X				
Palatability			X		
Browse Tolerance		X			
Moisture Preference	Moist to dry, withstands moderate flooding.				
Soil Preference	Medium to coarse textured.				

Agropyron dasystachyum (Hook.) Scribn.

SPECIES BIOLOGY

Taxonomy - Northern Wheatgrass

Cultivars Elbee and Critana (709, 720); thickspike wheatgrass (639).

Interspecific hybrids between northern wheatgrass and slender wheatgrass; and northern wheatgrass and streambank wheatgrass occur naturally in native stands (720).

Origin and Range

Native. It is widely distributed throughout the prairies. Northern wheatgrass extends from British Columbia east to Michigan, south to Colorado and Illinois.

Growth Habit

Resembles western wheatgrass but is greener (725). Northern wheatgrass is a cool season perennial, strongly rhizomatous, creeping, aggressive sod forming root system. It will form a tight sod under dryland conditions (720, 727). Elbee has a three-way rooting system: creeping underground rootstalks which spread and reproduce, a very shallow fiberous root system, and deep roots which penetrate to at least 60 cm. The plants are tufted with erect leaves and stems 45 to 75 cm tall.

Nitrogen Fixing - None

Longevity

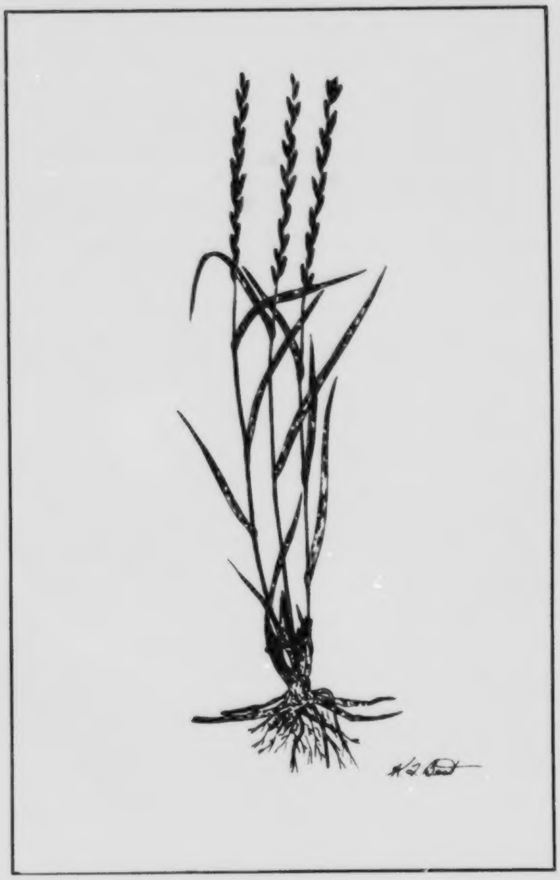
"Elbee" is a hardy long-lived perennial.

Self Propogation

It is a cross-pollinated species (605). High seed yield (716). Strongly rhizomatous (709).

Ecological Setting

Common to northern parts of the Great Plains and intermountain area (725). Common to both brown and dark brown soil zones, preferring dry areas. Found throughout mixed prairie and parklands (78). Found in varied habitats ranging from heavy soils at valley bottoms to lighter soils on hillsides (627). Critana is adapted to a mean annual precipitation zone of 25 to 40 cm. Requires 20 cm minimum (639). In areas with mean annual precipitation greater than 46 cm it is out performed by other species.



TOLERANCES

Soil Preferences

It is adapted to a wide range of soil conditions, but prefers dry medium to coarse textured soils and performs well on sandy soils or shaley clays (720, 727). Adapted to coarser textured soils than western wheatgrass (725).

Nutrient Requirements

It can be inferred from the ability of northern wheatgrass to establish itself on mine spoils, depleted rangeland conditions and eroded areas that its nutrient requirements may be low.

Soil Reaction

Elbee has been reported to tolerate a range of soil reaction (pH 6.0 to 9.5) and it tolerates considerable alkalinity (727).

Soil Salinity

It has moderate tolerance to salinity.

Drought Tolerance

It has excellent drought tolerance; More so than western wheatgrass (725).

Shade Tolerance

No specific references in the literature, but may be inferred to be relatively intolerant because of its range.

Grazing or Mowing Tolerance

It produces good quality hay, but is better suited for pasture as the plants cure on the stem and retain their nutrients over winter and the long creeping roots enable the plants to withstand heavy grazing and considerable trampling (720, 725).

Susceptibility to Disease and Insect Damage

Northern wheatgrass is susceptible to leaf stem rust especially under irrigation, but not under dryland conditions (720).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Has strong sod forming ability. Provides excellent erosion control because of its aggressive creeping rhizomes and relatively deep roots which bind the soil (605). Can be used alone in erosion control plantings (725).

Adaption to Disturbance

It has good adaption to disturbance as attested to its successful use in ecological repair and vegetation of industrial disturbed areas and depleted rangelands.

Competitive Ability

It is considered to be compatable with other species because of its wide adaption and because it is suitable for planting in mixtures with other forbs, grasses and shrubs.

Commercial Value

Suitable for rehabilitation of rangelands and erosion control. It is valued more for its special purpose applications than for its productivity as forage grass (605). Has yielded over 500 kg/ha under irrigation (720). Forage yield less than western wheatgrass (725). Elbee northern wheatgrass is well adapted for pasture and hay production in Brown, Dark Brown and Black soil zones in the prairies (716). Elbee is more productive in forage and seed than Critana in trials in Alberta and Saskatchewan but produced about 45% less forage than crested wheatgrass (716).

Palatability and Nutritive Value

Northern wheatgrass is considered to have good forage value for cattle.

Seed and Planting Stock Availability

Elbee (released 1980) is the first variety of northern wheatgrass to be released in Canada (Lethbridge) and seed is readily available. It is tolerant of cold, drought and alkali. Critana (released 1971) is another variety developed in Montana. It is suitable for reclamation of dry sites (605, 720). Approximately 154 000 seeds/lb (639).

Methods and Ease of Establishment

Seed holds well and can be combined. It has excellent germination, seedling vigour and early spring growth that suggest it is easy to establish under dryland or irrigation by drilling or broadcast. Establishes more rapidly than Sodar Streambank wheatgrass (720) and Western wheatgrass (725). Fall/spring seeding at a rate of 6 to 8 lbs PLS/ac is recommended (639).

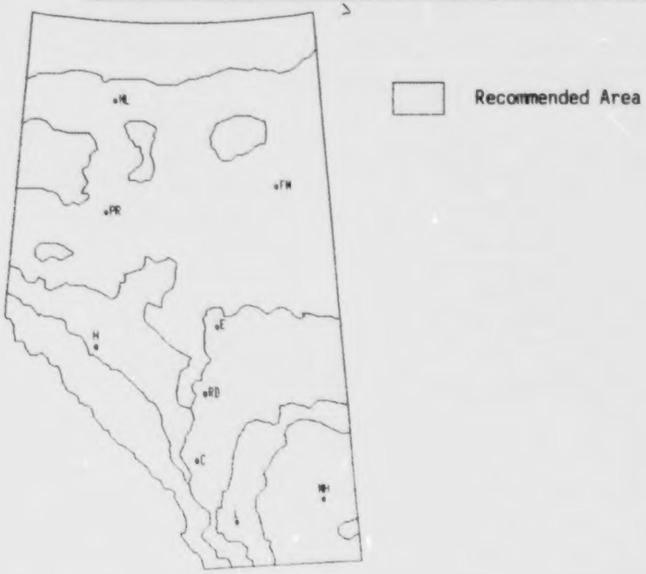
Current Status for Reclamation

Northern wheatgrass is valued for its special purpose applications. It is used in revegetation of industrially disturbed areas, such as oil and gas well sites, pipeline construction areas, roadside and other construction sites that will receive little or no maintenance. It has been used successfully on mine spoils and in range seedings in Montana and Wyoming (725). May be used for reseeding range sites that are severely eroded and have low fertility (709).

Northern wheatgrass has excellent germination, high seedling vigour and is easy to establish. Its resistance to drought along with its relatively procumbent spreading habit of growth makes it well suited for soil stabilization on dry and alkaline areas. It has also been used successfully on mine spoils and in rangeland rehabilitation.

Agropyron elongatum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No ___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance			X			
Salt Tolerance		X				
pH Tolerance	Acid					
	Base	X	X			
Winter Hardiness				X		
Erosion Control				X		
Persistence		X				
Palatability				X	X	
Browse Tolerance				X		
Moisture Preference		Moist to wet, withstands 3 to 4 weeks spring flooding.				
Soil Preference		Well drained to wet.				

Agropyron elongatum (Host) Beauv.

SPECIES BIOLOGY

Taxonomy - Tall Wheatgrass

Origin and Range

Introduced from Eurasia, notably Turkey, Asia Minor and the USSR (179, 426). Used throughout western North America especially on the Canadian prairies (47), and the American Great Plains and intermountain region (183).

Growth Habit

A tall, erect, loosely tufted bunchgrass (47). Typically stemmy, with coarse leaves (183, 179). Can be 120 to 180 cm high (183, 424), but the Canadian cultivar "Orbit" is more typically 100 to 110 cm in height (139). Fibrous root system (47).

Nitrogen Fixing - None

Longevity

Long-lived, cool season (639) perennial (391), with good overall hardiness (139). The species may be subject to winter killing (391); "Orbit" displays superior winter hardiness (183, 426). Late maturing (183, 391, 426, 179).

Self Propagation

Propagates itself primarily by reseeding (338). Good seed producer, large seeds, and good seedling vigour (183).

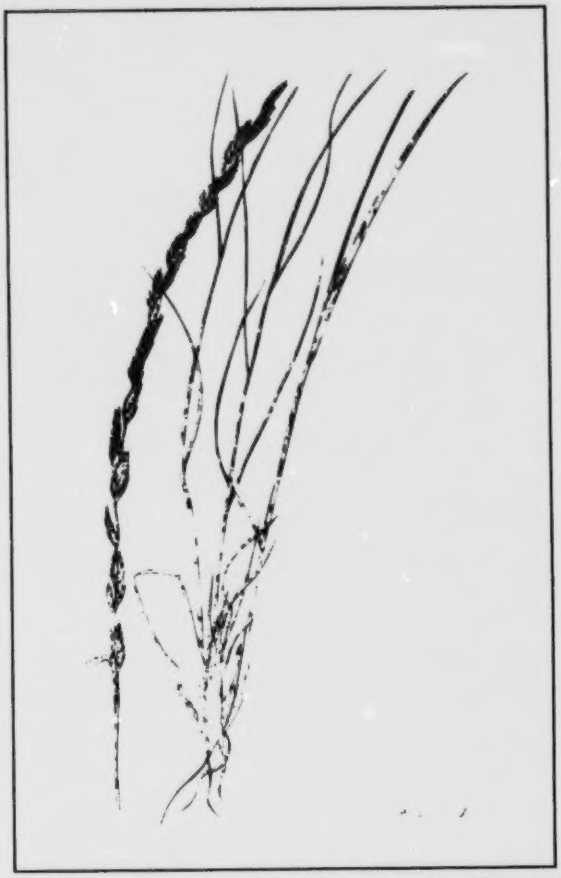
Ecological Setting

Occurs primarily in cultivated stands: hayfields and pastures (47). Also occurs (escaped) on certain dry and/or saline areas (338). Requires a minimum of 20 cm of precipitation (639).

TOLERANCES

Soil Preferences

Adapted to growth on well drained, imperfectly drained and wet soils (179, 391, 426, 12). Specifically adapted to Solonetzic soils, usually where these are in conjunction with brown Chernozems. Also found on Gleysols (179). Often the soils are alluvial, with high water tables and migrating leached salts (179). Does well when water tables are a few centimeters from the surface and also when the water table is barely within the rooting zone (340); withstands as much as 3 to 4 weeks of flooding in spring (391, 183). All but the most coarse textural classes are acceptable.



Nutrient Requirements

No specific requirements have been noted, however improved range and pasture lands in the U.S. are supplemented with nitrogen fertilizer annually (179).

Soil Reaction

Tolerant to very tolerant of alkaline soil conditions (391, 183, 179, 388, 422). No pH ranges have been noted.

Soil Salinity

Reputed to be "the most salt tolerant of all cultivated grasses" (47). General agreement that the species is highly adapted to saline soil conditions (391, 183, 422, 233, 340, 179, 468) and alkali conditions (639). Grown successfully where as much as 1% soluble salts occur (340). Variously noted to tolerate between 11 and 16 mS/cm (468, 125) and between 8 and 15 mS/cm (247). May tolerate even higher levels (422, 125).

Drought

A relatively high degree of drought tolerance (391, 340), though less drought tolerant than crested wheatgrass or the sod-formers, pubescent and riparian wheatgrass (34). Fared best (with pubescent wheatgrass) under droughty Texas test conditions (375). Its extensive root system reaches down as far as 3 m in search of water under suitable soil conditions (34). Requires a minimum of 35 cm of precipitation annually (179).

Heavy Metals and Hydrocarbons

Tolerant of 5% soluble boron content of spoil material when grown without amendment; this spoil also had high electrical conductivity (10 mS/cm) and sodium saturation (30%) (91). No other tolerances have been specifically noted.

Shade

May become weak and spindly when growing in shady areas (340).

Grazing or Mowing

Not as tolerant of heavy grazing as most introduced wheatgrasses; use in the growing stage should not exceed 60% (340).

Susceptibility to Disease and Insect Damage

No information located in the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Extensive fibrous root system produces a high tonnage of residue (179); substantial herbage yields also contribute to accumulation of large amounts of soil organic matter (183, 179). Considered a good soil stabilizer (338), although it is not recommended for steep slopes (422).

Adaption to Disturbance

Relatively well adapted to disturbance (338).

Competitive Ability

Seems to be a moderately good competitor especially under the extreme soil conditions for which it is adapted. For best hay and pasture however, tall wheatgrass is usually grown alone (391, 179).

Commercial Value

Produces fair hay (391) and its value for pasture is quite high (especially in alkaline-saline areas where high yield forage species usually do poorly), particularly late in summer when it stays green later than most species (391, 179, 340). Also useful for rehabilitating wet alkaline and saline lands (391) for other crops; with proper cultural methods, drainage, etc., "Alkar" tall wheatgrass (U.S. variety not licensed in Canada) will ameliorate conditions to allow alfalfa and other moderately tolerant species to take over (179). Also used for wildlife plantings (179, 426), and for silage (179, 391).

Palatability and Nutritive Value

Generally agreed to be at least moderately palatable for livestock (19) though less so than most other wheatgrasses (391, 183, 340). Apparently less palatable when found in mixed stands than when occurring in pure stands (340). Late maturity provides increasingly desirable forage into late summer and fall (391, 340). There is some evidence however that digestible protein and total digestible nutrients (TDN) are better than for crested wheatgrass (179). Palatability for sheep is equal to tall fescue (Festuca arundinacea), with yields as much as double (179).

Seed or Planting Stock Availability

Several commercial cultivars are available in the U.S. in quantity, namely "Alkar", "Jose", "Largo" and "Orbit" (183, 139, 430); Nebraska 98526 is undergoing testing(183). "Orbit" is the only cultivar licensed in Canada (138). Approximately 79 000 seeds/lb (639).

Methods and Ease of Establishment

Very good establishment by both seeding and transplanting (338). Reported to be easily established (391). Recommend planting in pure stands to optimize forage value. Where possible, a deep furrow drill should be used (179). A full season's protection should be provided, and preferably two seasons on dryland (no grazing). Setting seed at least once aids good establishment. Leaving a 15 cm stubble after cutting will ensure protection from potentially injurious grazing (179). Occasional fertilizations are recommended. A spring seeding at a rate of 8 to 10 lbs PLS/ac has been recommended (639).

Current Status For Reclamation

Widely used to cope with, and combat, saline and alkaline soil problems related to pasture and hay use (47, 391). Performed poorly in a grass/legume mixture at Fort McMurray on amended tailings sand, dying out after 5 to 7 years (645).

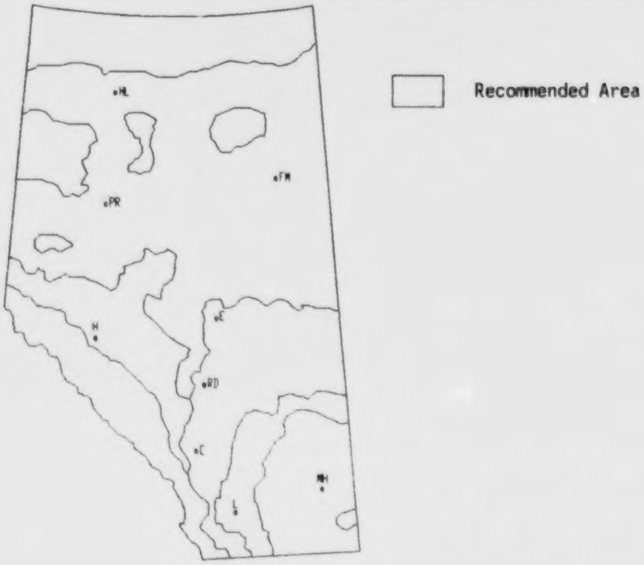
Though it has been tested in British Columbia interior on several metal mining refuse substrata, it has fared rather poorly (143); reasons are not readily apparent and more investigation is required.

Tall wheatgrass has a very good performance record at the Decker Coal Mine in Montana, where excess soluble salts and exchangeable sodium are a problem (117, 328). Other western U.S. mines are also having encouraging results (90).

Major assets of tall wheatgrass are its tolerance to high levels of alkalinity and salinity, tolerance of boron-containing spoils, tolerance of flooding and high water tables, relative ease of establishment under these conditions, high forage yields and extensive root system.

Agropyron intermedium

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base			X	X	
Winter Hardiness			X		
Erosion Control		X			
Persistence		X			
Palatability		X			
Browse Tolerance			X	X	
Moisture Preference	Moist.				
Soil Preference	Well drained, fertile.				

Agropyron intermedium (Host) Beauv.

SPECIES BIOLOGY

Taxonomy - Intermediate Wheatgrass.

Origin and Range

Introduced from Eurasia, Turkey the USSR and China (183, 199, 340). Similar to pubescent wheatgrass (*A. trichophorum*), except for lack of pubescence on seedheads; the two cross-pollinate and hybridize easily (179, 339). Planted throughout western Canada and the western U.S.; common in areas where smooth brome (*Bromus inermis*) is adapted (391).

Growth Habit

An erect, leafy sod-forming grass (183, 47) which generally attains heights in excess of 100 cm (100 to 120 cm) (139). A mild to aggressive sod-former of rhizomatous habit (short rhizomes) (183, 179, 47) with quick establishment and growth characteristics.

Nitrogen Fixing - None

Longevity

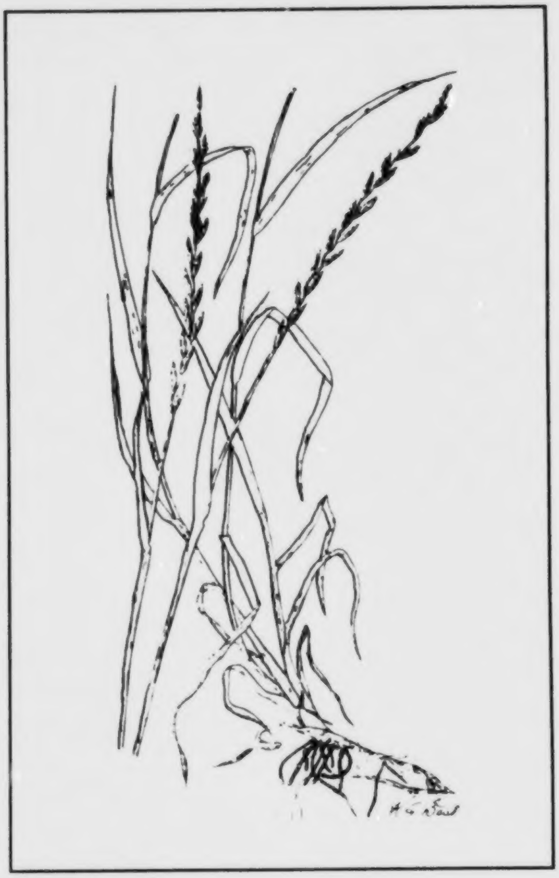
Long-lived, cool season (639) perennial, though shorter-lived than crested wheatgrass (*A. cristatum*) (391). Stands deteriorate rapidly if poorly managed (391). Reasonably good winter hardiness (183). Good pasture is difficult to maintain past 5 years (391).

Self Propagation

Medium natural reseeding ability and good natural vegetative growth (338). Though rhizomes are usually short, plants spread relatively aggressively under good moisture conditions (391, 179).

Ecological Setting

Primarily occurring in plantations for pastures and range and for revegetated disturbances within its adapted range (199). In Alberta, most common in the aspen parkland (47) and mixed grass prairie. Intermediate wheatgrass prefers moist sites (12) which receive at least 35 to 38 cm of precipitation annually (183, 639). The species is probably restricted to elevations below about 1 600 m ASL, based on research near Sparwood, B.C. (494, 498). Northerly and westerly exposures seem to be preferred (422, 498). At higher elevations, plants lack vigour and may not set seed (340). Will not persist in the high subalpine (41).



TOLERANCES

Soil Preferences

Best on well drained, fertile soils that receive ample moisture. Its aggressiveness as a sod-former is enhanced by irrigation (391). Soil classes preferred include the Chernozems and Podzols extending from the better brown soils through to alluvial types (179). Medium textured soils are best (179).

Nutrient Requirements

May become sod-bound on low fertility lands (340). Requires medium fertility (500).

Soil Reaction

The species prefers non-alkaline land (179), though it tolerates alkalinity better than acidity (338).

Soil Salinity

Moderate tolerance to salinity; will withstand electrical conductivities in the range of 5 to

10 mS/cm (468, 125). This tolerance is comparable to alfalfa and crested wheatgrass.

Drought

Intermediate in drought tolerance among the Agropyron group. Superior to slender, bearded, tall and western wheatgrasses,but inferior to crested, streambank, bluebunch and pubescent wheatgrasses (340). It can withstand no less than 28 cm of precipitation annually (339).

Heavy Metals and Hydrocarbons

No particular tolerances to heavy metals have been noted from the literature.

Shade

Not very well adapted to shade (340), but performs well in competitively suppressing undesirable shrubs which in some cases shade it, in Utah. It also withstands high temperatures associated with the arid Utah lowlands (Lower Sonoran zone) (339).

Grazing or Mowing

Often short-lived when grazed (47). Care should be taken in grazing the stands, even when mixed with alfalfa; moderate rates of grazing produce good results (179). Tolerance is generally excellent (339).

Susceptibility to Disease and Insect Damage

High tolerance to snow mold (50). Appears to be more resistant to leaf blight than pubescent wheatgrass (A. trichophorum) and is therefore often preferred (340). The "Tegmar" cultivar is more resistant to Banks grass mite than other strains of intermediate wheatgrass (183). Stems are strong and resist lodging (179). Resistance to insects and disease is considered good, relative to other grasses considered for seeding of big game range in Utah (339).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Root production is extremely good. A five year old stand in a mixture with alfalfa produced over 12 000 kg/ha of roots in the top 20 cm of soil; about 70% of this was provided by the grass. Soil structure and resistance to erosion was greatly improved (179). Intermediate wheatgrass is considered an excellent soil stabilizer (338).

Adaptation to Disturbance

Adaptation to disturbance is good (338).

Competitive Ability

Its sod-forming habit ensures its good competitive abilities (183). The species is also very compatible with alfalfa for pasture or hay. Phenology is such that the grass is not quite ready to flower when the alfalfa is ready to cut, resulting in excellent quality hay. This practice seems not to affect the longevity of the stand (179). Intermediate wheatgrass is able to competitively suppress shrub growth (339).

Commercial Value

Chief value is as a pasture and hay crop, though it is also well suited to erosion control including steep slope stabilization (422, 183). Intermediate wheatgrass is often substituted for smooth brome (Bromus inermis) in conservation mixes because of its higher forage production in non-irrigated lands. It is also better suited to the semi-arid brown soils (179). The species can be planted in combination with adapted bunchgrasses (eg. crested wheatgrass) to form a continuous mat (339).

Palatability and Nutritive Value

Palatable to all classes of livestock (47). Forage value for cattle is considered good (19). More palatable after heading than crested wheatgrass (340). Considered highly palatable on Utah ranges, and preferred forage during critical periods (339). Hay yields are higher than for most other adapted grasses; constitutes excellent pasture, through to late summer (391).

Seed or Planting Stock Availability

"Clarke" replaces "Chief" as the commercial cultivar available in western Canada. It outyields most grasses in the dark brown soils and under moderately dry conditions "Clarke" will out-produce crested wheatgrass. Five commercial cultivars are available in the U.S. "Amur" originated in China. Though vigorous, it is a slow sod-former with high seed yield. "Greenar" (Reg. No. 3) is an early cultivar which is vigorous, a moderate sod-former, disease resistant, and very productive. It is late maturing, shows good recovery and is widely used for conservation planting. "Oahe" (Reg. No. 5), obtained from the USSR, is tall, vigourous and has high yields of both seed and forage. "Slate" is one of the more strongly spreading cultivars. "Tegmar" is a dwarf strain. It is long-lived, strongly spreading and more drought tolerant. It is well suited to waterway planting and erosion control (183). Approximately 88 000 seeds/lb (639).

Methods and Ease of Establishment

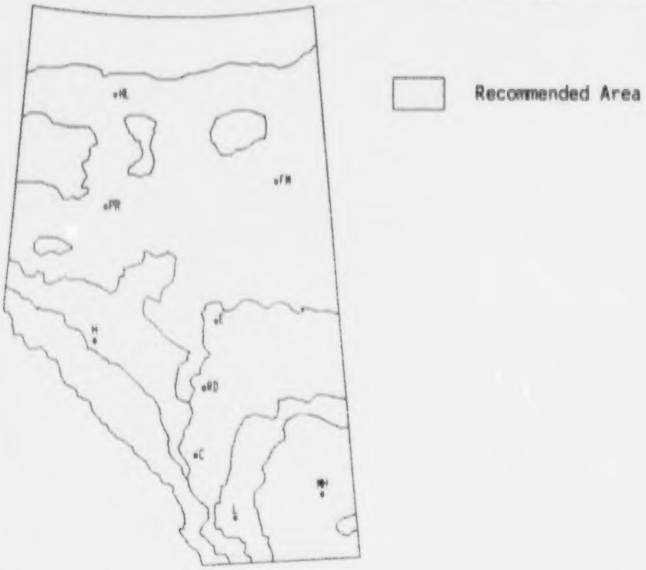
Excellent success by both seeding and transplanting (338). Excellent seedling vigour (41). Plantings should be treated similar to pubescent wheatgrass. Seed retains its viability (70%) for 6 to 10 years under cool, dry warehouse storage (179). Achieves a very good growth rate (338). A fall/spring seeding at a rate of 8 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

Widely used in Canada and the U.S. as a pasture and hay species, and to some extent for erosion control along waterways and such areas (183, 179, 391). Used to reclaim some mine lands in the semi-arid intermountain and Great Basin regions(422). Intermediate wheatgrass has been used at three metal minesites in the B.C. interior with moderate success on waste rock and overburden, but poor success on tailings (143). Trial success in the Upper Mackenzie Region of the Boreal Forest was acceptable at latitude 65° N (Sans Sault Test Facility) (111) and excellent with "Clarke" after three seasons at latitude 63° N (644). Encouraging results have been recorded in mine site trials at Grande Cache, Alberta (268, 271). Apparently the species is less widely adapted than pubescent wheatgrass (A. trichophorum) (500).

Agropyron pectiniforme

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance			X	X	
pH Tolerance Acid					
pH Tolerance Base			X		
Winter Hardiness	X				
Erosion Control	X	X			
Persistence	X				
Palatability		X	X		
Browse Tolerance		X	X		
Moisture Preference	Dry.				
Soil Preference	Medium to moderately coarse texture.				

Agropyron pectiniforme Roem. and Schutt.

SPECIES BIOLOGY

Taxonomy - Crested Wheatgrass

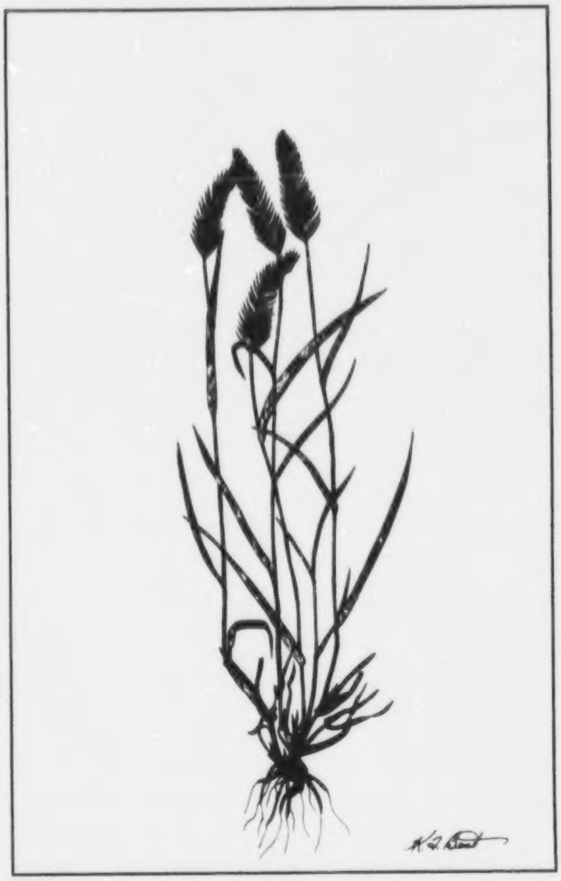
A. desertorum (Fisch.) Schult.
A. sibiricum (Willd.) Beauv.
A. cristatum (L.) Gaertn.

Origin and Range

All strains, varieties and species were acquired from the USSR, notably Russia and Siberia (183, 199). In the United States, particularly since 1950, the Fairway variety (A. cristatum) has been distinguished from the Standard type (A. desertorum) as a different species (the former is diploid, the latter tetraploid, and apparently little or no natural hybridization occurs) (183, 339). Most authors recognize the two as separate, though decidedly similar in habitat, growth habit, and appearance. Some authors, however still treat the two as varieties of A. cristatum (104). Siberian wheatgrass (A. sibericum) is probably also a distinct species, though closely related. A. cristatum predominates in Canada, being widely used in the western provinces, and to some extent used in the American northern Great Plains; Standard crested wheatgrass or desert wheatgrass (A. desertorum) is most common in the United States Great Plains. They both occur in both countries, however (183, 339). Siberian wheatgrass (A. sibericum) is less widely distributed in eastern Europe, and Russia through Siberia. All three have been naturalized and now occur from B.C. and the prairie provinces through Ontario, the Dakotas, Wyoming, Colorado, New Mexico and west to California (199). Their distribution elsewhere in North America is more sporadic, but extends through the mid-western and New England States, Labrador, the Yukon, N.W.T., and Alaska (214, 346).

Growth Habit

The species are all medium height bunchgrasses, and have various spreading abilities. Plants are erect and tufted (365, 348). Standard crested wheatgrass is taller than Fairway (about 50 to 75 cm versus 40 to 60 cm), more tufted, has coarser stems and leaves, and is less leafy (210, 139, 424). Siberian wheatgrass more closely resembles standard crested wheatgrass (183), but is reported to be taller (424), and is awnless (179). Standard is a typical bunchgrass; one ecotype is dwarf and tends to be rhizomatous (339, 179). Fairway is also a bunchgrass form, but is weakly rhizomatous (179) and tillers from the base to produce a persistent, tough sod (339). Siberian is another bunchgrass type.



Nitrogen Fixing - None

Longevity

Both Fairway and Standard crested wheatgrass are extremely long-lived perennials, often remaining productive for 30 years or more, even under conditions of occasional drought (286, 391, 179). Mortality is virtually unknown (286) in established stands. Mortality has occasionally occurred where extreme drought took place during a critical phenological stage (286). Crested wheatgrass is a cool season grass (639).

Self Propagation

The natural reseeding ability of these is considered excellent (338, 339). Seed production is generally very high, germination is excellent (339). A. desertorum, in particular, has the ability to germinate on harsh sites under conditions of low temperature and intermittent drought (474). Natural vegetative reproduction is less well developed; all species spread somewhat (rated fair) but Fairway crested wheatgrass produces tillers and rhizomes, and is therefore a good sod-former (338, 339, 179). The ability of Fairway to reproduce vegetatively probably accounts for its greater success at higher elevations where seed is not always able to mature (340).

Ecological Setting

These forms are all adapted to dry rangeland conditions and are most frequently found in these situations (391, 47, 339). They prefer at least 23 to 38 cm of annual precipitation (426, 639). They are most common on dry, open plains; Standard is generally limited to these locations, whereas Fairway is also adapted to favorable sites with more moisture, even at higher elevations and in tundra or taiga situations (391, 339, 312). Siberian wheatgrass is somewhat less adaptable than either of the other forms, and is more restricted in its occurrence (339). Standard crested wheatgrass (A. desertorum) would not reproduce at elevations exceeding about 1 600 m ASL on dry slopes in southeastern B.C. (498), however Fairway is known to occur 300 to 500 m higher at many locations in Utah, Idaho and Wyoming (210, 340). At higher elevations, Fairway is more persistent than Standard (340).

TOLERANCES

Soil Preferences

Standard crested wheatgrass is most common on medium and moderately coarse textured soils. These are often Chernozemic, Solonetzic, Regosolic, or extremely shallow soils (179). Growth is also expected to be good on some Brunisols and Luvisols. Suitable soils are normally well drained, and moist or dry (12, 391); deep, well-drained loamy soils (639). Siberian wheatgrass is also adapted to light droughty soils (183, 179). Fairway wheatgrass (A. cristatum) is a hardy species on these dry soils as well, but it also survives and does well under more moist conditions (339). The species will not withstand prolonged flooding (183, 426).

Nutrient Requirements

Considered to have low to medium fertility requirements (500). The extremely wide adaptations of these species, their persistence on marginal and unfavorable sites, and their common occurrence on normally low nutrient mountain and foothill soils suggest that their nutrient requirements are rather modest.

Soil Reaction

These species are all adapted to moderately alkaline conditions (179, 339, 338).

Soil Salinity

Standard and Fairway crested wheatgrasses are both adapted to at least moderate levels of salinity (339, 422). Tolerances in the ranges of 5 to 10 mS/cm and 8 to 15 mS/cm have been identified (247, 468, 125). Emergence in the greenhouse of pregerminated seed and untreated seed was initially highest in 16 mS/cm solution; however after 17 days emergence was greatest in solutions of 0 and 4 mS/cm and much lower in solutions of 8 and 16 mS/cm; the pregerminated seed had significantly better emergence after 17 days than the untreated seed (691). Crested wheatgrass seed had better emergence in the 16 mS/cm solution than Russian wildrye, but poorer than western wheatgrass (691). Standard crested wheatgrass is somewhat less salt tolerant than Fairway (339).

Drought

These are extremely drought resistant species (391, 183, 340, 256) surpassing virtually all other wheatgrasses (340).

Heavy Metals and Hydrocarbons

Fairway crested wheatgrass, simply known as crested wheatgrass (A. cristatum) in Canada, performed satisfactorily on ameliorated ash lagoon material (high in boron) at Wabamun (305). No other sensitivities or tolerances were identified from the literature.

Shade

Fairway is more shade tolerant than Standard, but both prefer not to be shaded (391, 210).

Grazing or Mowing

Good to very good tolerance to grazing (339). All of these species are very resistant to heavy grazing (183, 286). Under dry conditions seedlings are slow to develop, and should be protected from grazing for the first two years (179).

Susceptibility to Disease and Insect Damage

Some varieties are resistant to leaf and stripe rusts

(179). Variable resistance to snow mold (50). Susceptible to black grass bug (Labops sp.) in pure plantings (P. Ziemkiewicz, pers. comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

These grasses are among the best erosion controlling bunchgrasses due to the slightly rhizomatous and sometimes tillering habits (339). Fairway, particularly, is important for stabilizing reservoir berms, highway cuts and fills, and for turf purposes (179, 183). Both are noted for strong rooting abilities and root biomass production (179). Notably successful on both dry and moist slopes, even where these are steep (422, 498). Roots may extend past 2 m (138).

Adaptation to Disturbance

Good adaptation to disturbance (338), particularly under droughty conditions.

Competitive Ability

Crested wheatgrass is considered to have good compatibility with other species and because of its wide adaptation is suitable for planting in mixtures with other grasses, forbs and shrubs (339). Planting in combination with more narrowly adapted species is useful on ranges of varying alkalinity (339); this would undoubtedly be a good technique for variably inundated and eroding sites as well. Planting alone and with alfalfa is common practice (179). Considered a medium aggressor (500). The varying sod forming abilities of both forms of crested wheatgrass and their notably high longevity and persistence, suggest that they are strong competitors under dry rangeland conditions. For this reason crested wheatgrass is not recommended for use where "native prairie" is to be maintained in Alberta (B. Adams, pers. comm.).

Commercial Value

Suitable for rehabilitation of rangeland in poor condition, conversion of marginal cropland to grass (179, 341), pasture and hay, erosion control, dryland lawns and turf (183), and wildlife range (422).

Palatability and Nutritive Value

A. cristatum is considered to have good forage value for cattle (19). Palatability is moderate to good throughout the year, but the species are much more important in spring due to their earlier emergence, growth and maturity (339, 183); they provide forage ahead of the native grasses. This benefits livestock and wildlife alike (339, 183). Overall, Fairway is slightly more palatable than Standard (339), but yields of Standard are higher, with Siberian wheatgrass yielding highest of all (179). Siberian also remains green 10 to 15 days longer and is more digestible (less lignin) than Standard crested wheatgrass (179).

Seed or Planting Stock Availability

Several cultivars of each of these species are available. Though the term "Fairway" is widely used in the U.S. to describe A. cristatum, it is considered a licensed cultivar in Canada (426, 138). "Parkway" is also licensed in Canada (138). Other A. cristatum cultivars include "Ruff" (426) and "Musla" (139). A. desertorum is available as the (Standard) cultivar "Nordan" (Reg. No. 2); "Summit" is also licensed in Canada. A dwarf cultivar, which is rhizomatous, favors higher altitudes but is less productive, and is still undergoing testing (183, 139, 340, 500, 138). There is one cultivar of Siberian wheatgrass available in the U.S., namely "P-27" (179, 183). Other US varieties include Ephraim and Hycrest. There are approximately 200 000 seeds/lb (639).

Methods and Ease of Establishment

A. cristatum is considered to have excellent establishment qualities for direct seeding, transplanting or sod introduction (339, 338). Probably because of this establishment flexibility it is considered superior to both A. desertorum (Standard) and A. siberium (Siberian). All are excellent germinators. All three are acceptably good as transplanting stock (339). Seed of crested wheatgrass can be stored in dry, cool surroundings for as much as 12 years, retaining 70% viability (179). Crested wheatgrass establishes well through seeding, but prospects improve with improved seedbed preparation. Drilling is preferred to broadcast seeding, and deep furrow drills produce best results (179). Fall and spring seeding at a rate of 10 to 20 lbs PLS/ac is recommended (639).

Current Status for Reclamation

Both forms of crested wheatgrass (the various Standard and Fairway types) are widely used for range and cropland rehabilitation, erosion control, and for reclamation. Siberian is less widely utilized (183, 339, 179). The crested wheatgrasses have been used or tested for reclamation of a wide variety of disturbances in western Canada including: tests and operations at Camrose-Ryley (340), and

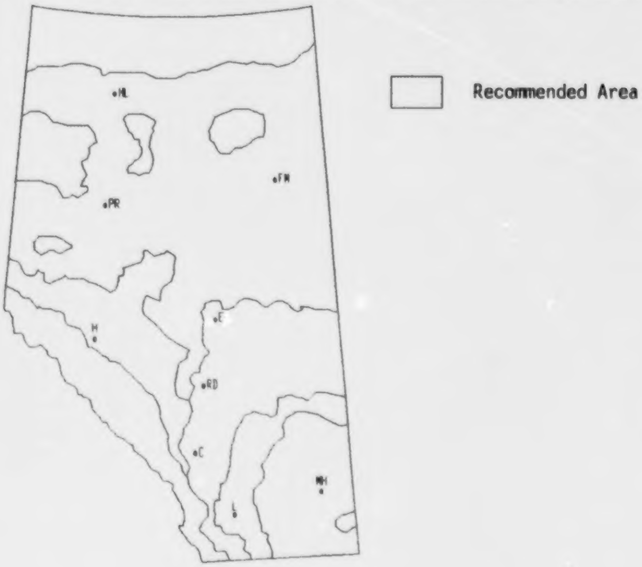
Highvale and Whitewood mines at Wabamun (304, 280) including ash lagoon revegetation trials (305); encouraging trials at the Cardinal River mine at Luscar (259) and at Grande Cache (268, 354, 267); high survival and vigour (Fairway) after five years testing in subalpine sites along the Rocky Mountains eastern Slopes (705) and after three years testing at lat. 63°N in the Mackenzie River Valley, but performed poorly on tundra sites (644); on mine spoil at Poplar River, Saskatchewan (290), and Estevan (180); encouraging trials on sand at Lesser Slave Lake (249, 257, 258); persisting (Norday) in mixed seedings at Fort McMurray on tailings sand soil mixtures and on overburden on dry sites for 17 years (643) but declining rapidly in tailings sand soil amendment trials on moist sites (704); also performed poorly (Fairway) in grass/legume mix on topsoil and overburden on moist sites at the Judy Creek test mine (646). In B.C., tests and operations are underway at Craigmont Mines (165), at Kaiser (498), and results from 7 metal mines in the B.C. interior indicate excellent success on waste rock and good success on overburden and tailings (rated as the best agronomic for metal mine revegetation in the B.C. interior) (143).

In the U.S., success has been recorded at dry sites in the Alaska interior (298), at high elevations in Colorado (236), at West Decker mine in Montana (117), at Bull Mountains test plots in Montana (129), at the Carter bentonite mine in Montana (328) and at the Bighorn coal mine in Wyoming (328). Numerous tests have been conducted elsewhere regarding such problems as heavy metal uptake (141).

The impressive success and wide use of the two crested wheatgrasses (A. cristatum and A. desertorum) can be attributed to exceptional drought tolerance, moderate alkalinity-salinity tolerance, high seed yield, variable sod-forming tendencies, low nutrient requirements, good soil stabilizing abilities, rapid establishment, early maturity, good palatability and extreme longevity. Weak characteristics are few, but may include low tolerance for wet or shady conditions and elevational limitations. Not recommended where "native" prairie is to be maintained.

Agropyron riparium

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance			X		
pH Acid			X		
Tolerance Base			X		
Winter Hardiness		X	X		
Erosion Control	X	X			
Persistence	X				
Palatability				X	
Browse Tolerance		X			
Moisture Preference	Moist to dry.				
Soil Preference	Well drained soils, tolerates wide textural range.				

Agropyron riparium Scribn. and Smith

SPECIES BIOLOGY

Taxonomy - Streambank Wheatgrass.

Origin and Range

Native to North America. Found in western Canada and the northwestern United States (199, 426).

Growth Habit

Low growing, sod-forming grass (426, 232) with stems 30 to 80 cm high (78). Vigourous rhizomes (199, 179, 187). Relatively low biomass yield (139) due to short size of plants and narrowness of leaves (391).

Nitrogen Fixing - None

Longevity

Long-lived, cool season (639) perennial (391, 179), showing good winter hardiness (240).

Self Propagation

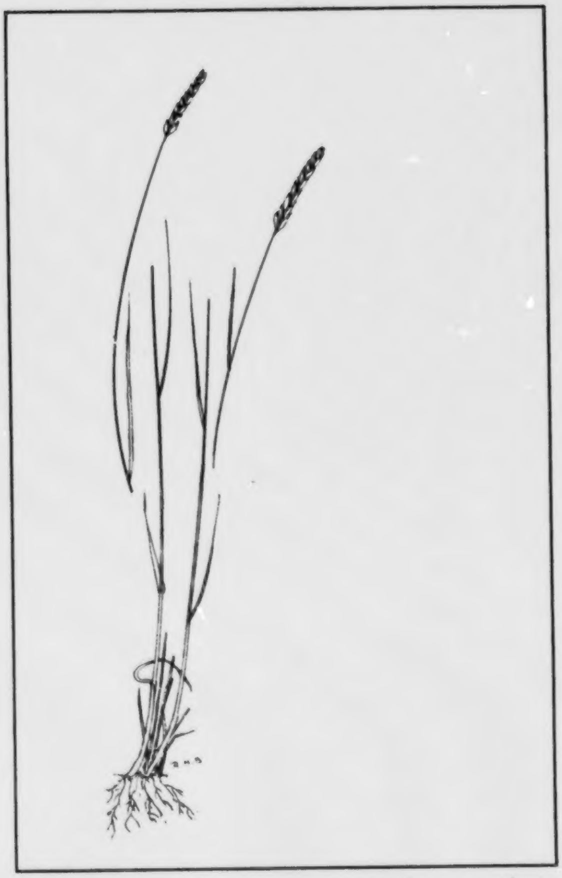
Reproduces both by seed and vegetatively through a spreading root system (338, 179, 187). Low seed yield (139) and rather poor natural reseeding ability (338); this is compensated for by very good spreading by vegetative means (179, 338).

Ecological Setting

Dry or moist meadows and hills (199). Requires minimal precipitation (and soil moisture); where evapotranspiration is high, often at lower elevations, 30 cm of precipitation is recommended, however only 23 cm is necessary where water loss is noticeably reduced (426, 179). A minimum of 20 cm rainfall required (639). Native to dry forest (338) and grassland communities. Not regarded as adapted to the higher subalpine (359), although at least three years successful growth noted at 2 340 m in Alberta (D. Walker, pers.comm.). Occurs in both natural and revegetation settings at over 1 600 m ASL in the Alberta foothills (259, 455). Growing season requirement is less than 120 frost-free days.

TOLERANCES

Soil Preferences



Prefers well drained soils, notably Chernozems (179). Textural classes can range from sandy to clayey (426). Notably successful emergence on carbonaceous materials, bentonitic clays and gritstone (187). Though emergence was not affected, biomass increased when topsoil was added (187) at Hat Creek, B.C. tests. Is successful in Montana under both low and moderate moisture conditions (422).

Nutrient Requirements

Maintained better cover, in conjunction with legumes, and in combination with other grasses, when fertilizer applications were only moderate (359).

Soil Reaction

Tolerant of mildly acid (338), and moderately alkaline conditions (391, 183, 179).

Soil Salinity

Moderate tolerance to saline conditions (424, 422).

Drought

Relatively drought tolerant (391, 183, 179, 426).

Heavy Metals and Hydrocarbons

No information reviewed points to particular heavy metal tolerances. Appears to have some tolerance to carbonaceous (coaly) materials, at least in the emergence and early growth stages (187).

Shade

No relevant information reviewed. Presumably has no more than modest tolerance to shade, since the species is most successful in arid environments where its tolerance to drought gives it an advantage over competitors.

Grazing or Mowing

Low palatability precludes grazing pressure. Apparently the species withstands mowing very well due to its extensive use for lawns and heavy use (traffic, trampling) areas.

Susceptibility to Disease and Insect Damage

Specific information is generally lacking. Some evidence of powdery mildew and head smut effects in the oil sands area (359).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Provides good protection for soil surfaces and prevents encroachment by weeds (183, 179). Particularly well adapted for erosion control, its primary use (183, 391, 187). Ranked very high for soil stabilization ability (178, 338). As with grasses generally, it offers good potential for increasing organic matter content of soils. Successful on steep slopes (422).

Adaptation to Disturbance

Good adaptation to disturbance (338) attested to by success on such sites as cut and fill slopes, highway margins and parking lots (179).

Competitive Ability

Highly competitive to weeds and other plants under dryland conditions (183, 179, 183). Plants are easily crowded out by other grasses, however, if the site is wet (179).

Commercial Value

Major value is for surface stabilization and erosion control (391, 183, 426, 187, 179). Applications of "Sodar" cultivar include cover for highway shoulders, cut and fill slopes, borrow pits and median separators. It is used for grassing runways for small aircraft, and at large airports for stabilizing soils adjacent to runways and hangars. It provides a low, smooth sod suitable for playgrounds, parking lots, lawns and farmyards (183, 179). It requires low maintenance and infrequent watering (391). It is also favored for use on the banks of irrigation canals and drainage ditches (391, 183, 179). Low fire hazard due to low above ground biomass (179).

Palatability and Nutritive Value

Low palatability (427, 391). Low growth and narrow blade indicate low forage yield (391). Low palatability is an asset in highway revegetation and other schemes where animal use is discouraged.

Seed or Planting Stock Availability

One commercial cultivar is available in Canada and the U.S., namely "Sodar" (183, 138). "Sodar" was selected for low seed yield, although this is not necessarily a characteristic of the species. Approximately 156 000 seeds/lb (639).

Methods and Ease of Establishment

Can be established either by seeding or transplanting with good success (338). Relatively easily established (424) due to quick seed germination and good seedling vigour (179). Low maintenance requirements (391, 179). A fall/spring seeding at a rate of 6 to 8 lbs PLS/ac has been recommended (639).

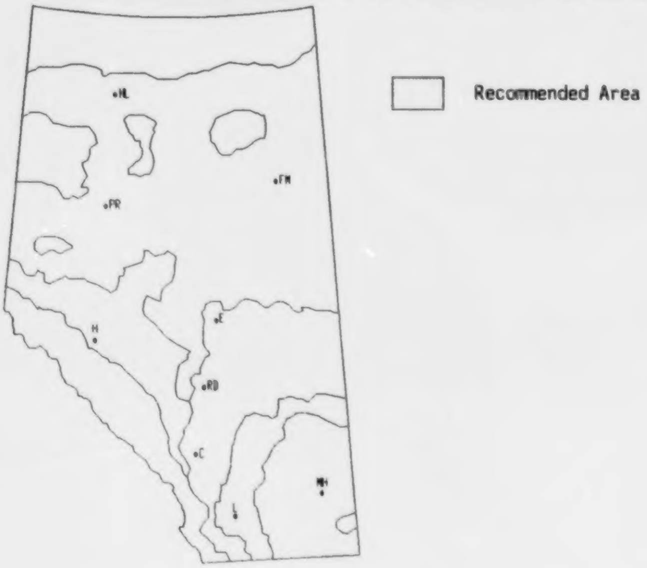
Current Status for Reclamation

Widely used for ground cover and stabilization associated with public use areas such as highways, airports, recreation areas, parking lots and irrigation canals (391, 183, 179). Streambank wheatgrass is being used with limited success at several metal mine reclamation sites in the southern interior of B.C. (143). It has achieved at least experimental success at several other locations; at Hat Creek (187), Luscar (259), and in Montana (422, 117). "Sodar" was found adequate for short-term (1 to 3 year) performance at Banff at 1 390 m (732) and at Fort McMurray it performed as well as other wheatgrasses after five years of testing on amended tailings sand (705). Results have been very discouraging for use in reclamation in the western arctic (111, 488).

For reclamation, its chief advantages are drought tolerance, moderate alkalinity and salinity tolerance, and its sod-forming habits which achieve very effective erosion control even on steep slopes. The species has low palatability, however, and under dry conditions can crowd out less vigorous competitors.

Agropyron smithii

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance		X	X		
pH Tolerance Acid			5.0		
Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence	X				
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Moist to dry, withstands spring flooding.				
Soil Preference	Clay and clay-loam textured.				

Agropyron smithii Rydb.

SPECIES BIOLOGY

Taxonomy - Western Wheatgrass

Also the variety *A. smithii* var. *molle* (Scribn. and Smith) Jones.

Origin and Range

Native throughout most of northern North America, but well south of arctic treeline(214). British Columbia and Alberta, east to Ontario, south to New York, Tennessee and Texas, and west again to northern California (199). Introduced to Alaska (214), and in the U.S. east of Iowa and Kansas (199). Isolated occurrences in Iceland, Quebec and the Northwest Territories (214).

Growth Habit

Erect, loosely tufted, low growing sod-forming grass, with long, slender creeping rhizomes (214, 199, 47). Ranges from 30 to 60 cm in height, sometimes taller (199) and occasionally less (20 cm) (424). Most strains produce open sod, but tight sod is typical of at least one cultivar (183).

Nitrogen Fixing - None

Longevity

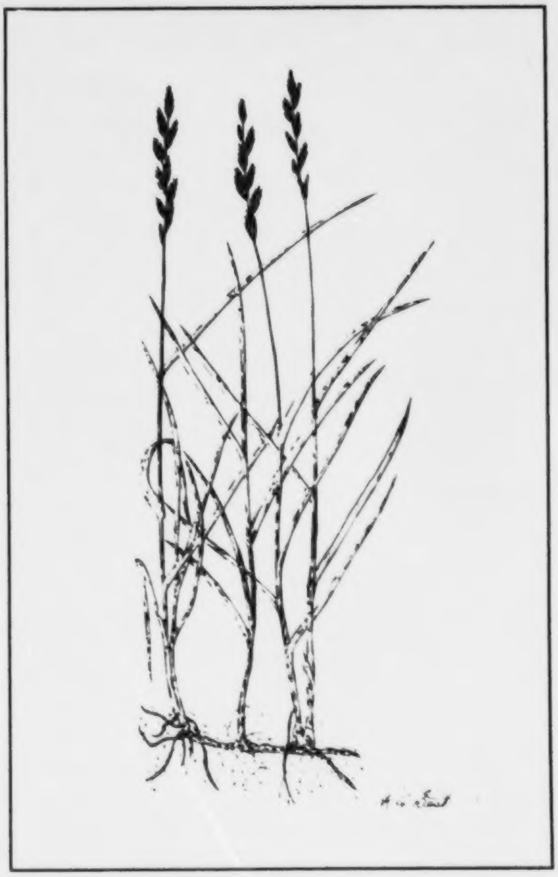
Long-lived, cool season (639) perennial (244).

Self Propagation

Though seed production is often high (183), the species is considered a poor natural re-seeder. During unfavorable years, seed production may be greatly reduced (231). It has excellent capability for vegetative spreading (338). Rapid germination and good seedling vigour (183). Slow to establish from seed (605).

Ecological Setting

Most common on heavy soils and in swales where moisture collects (489, 47, 179). Minimum of 25 cm of rainfall required (639). Survives in mixtures even where annual precipitation is less than 30 cm (340), though it prefers 35 cm or more under dryland conditions(429). Usually found on flat to moderately rolling topography (429). A prairie species, losing importance northward in Alberta (455) due to growing season requirements (needs 120 to 150 frost-free days). Collected at Greenville Mountain, Alberta (1 050 m) (455). Often associated with blue grama and the needlegrasses in the Great Plains (605).



TOLERANCES

Soil Preferences

Adapted to fine and medium textured soils (429). Withstands considerable flooding and silt deposition, and fares well in swales where moisture accumulates. Production is lower on the lighter soils (340).

Nutrient Requirements

Presumably requirements are at least moderate for nutrients due to its affinity for water collection areas.

Soil Reaction

Tolerance to alkaline soil conditions (244, 422, 47) is at least moderate (183). Satisfactory survival can also be expected for acidic pH's above 5.0 (228).

Soil Salinity

Moderate (424) to very high (361) salt tolerance. "Walsh" performed well on a heavy clay mud-flat with electrical conductivities ranging from 9.1 to 21.2 mS/cm (717). Emergence in the greenhouse of pregerminated seed and untreated seed was initially highest in 16 mS/cm solution; however after 17 days emergence was greatest in solutions of 0 and 4 mS/cm and much lower in solutions of 8 and 16 mS/cm; the pregerminated seed had significantly better emergence after 17 days than the untreated seed (691). Western wheatgrass seed had better emergence in the 16 mS/cm solution than Russian wildrye and crested wheatgrass (691).

Drought

Established stands endure long periods of drought (179). Emergence of seed 24 days after sowing was significantly better in soils at field capacity than soils which were "moderately dry" or "dry"; however, there were no effects on root or shoot length or weight (691).

Heavy Metals and Hydrocarbons

No particular tolerances to heavy metals or hydrocarbons were noted from the literature.

Shade

Not highly shade tolerant, but does well in an open brush setting (340).

Grazing or Mowing

Was found to decrease under heavy grazing by sheep (389). It would seem that the species is most sensitive to grazing pressure during its initial establishment period.

Susceptibility to Disease and Insect Damage

Susceptible to leaf and stem rusts under heavy irrigation, though resistant under dryland conditions (429). Susceptible to "take-all" (Ophiobolis graminis) under irrigation. Periodically infested with clay-backed cutworms (429).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

High soil stabilization potential (244, 338). Survives satisfactorily on steep slopes if drought, typical of southern exposures, is avoided (422).

Adaptation to Disturbance

Good adaptation to disturbance (338). Observed to invade disturbed sites and certain mill tailings in the subalpine zone (41).

Competitive Ability

The aggressive spreading root system is extremely competitive and resists invasion by other species (340).

Commercial Value

Useful for irrigated and dryland pasture and hay, and stabilization of swales, overflow sites and waterways (429). Other uses include natural range, wildlife habitat, fairly heavy use recreation areas and erosion control (422).

Palatability and Nutritive Value

"Arriba" is palatable to all forms of livestock (321). Good forage value for cattle and wildlife (381). The young spring growth is most palatable, but the grass becomes coarser and less palatable by early summer (183, 179). Authors are not agreed on this latter point, however, sometimes stating the opposite relationship (340). Leaves cure well on the stem, providing a good source of winter grazing (605). Relatively highly digestible, though crude protein content decreases significantly with maturity (231). In mixed stands with native bunchgrasses, the bunchgrasses are generally selected first; continuous early spring grazing of these may result in pure stands of western wheatgrass (179).

Seed or Planting Stock Availability

One cultivar, "Walsh", is available in Canada since 1983. "Walsh" produced about 5% more dry matter than "Rosana", a U.S. cultivar, on dryland trials at Lacombe and Lethbridge, Alberta, and Swift Current, Saskatchewan. "Walsh" outyielded "Sodar" streambank, "Revenue" slender, "Nordan" crested, and "Chief" intermediate wheatgrass on a moderately saline, heavy clay mud-flat at Stirling, Alberta (717).

Three cultivars are commercially available in the U.S. "Barton" was developed in Kansas, and is a high yielding, relatively disease resistant strain (183). "Rosanna", best adapted for western Canada, was acquired and tested in Montana, and is very strongly rhizomatous, producing tight sod. It has superior seedling vigour, and good forage and seed yield (183, 430, 429). "Arriba" is a Colorado strain with high seed yield, good emergence, seedling vigour and forage production. It is palatable for livestock, a good soil stabilizer, and average in its tolerance to mites and rust (321). Seed is sometimes in short supply, and can be fairly expensive (132). "Rodan" is also available (639). Approximately 110 000 seeds/lb (639).

Methods and Ease of Establishment

Root systems develop slowly in the seedling stage, and mortality at this time is often high if drought is experienced soon after germination (340). Sometimes difficult to establish in the subalpine (41). Rated as having only fair ease of establishment on moderately dry Colorado ranges (424). Where possible, seed should be drilled to afford extra protection in the early growth stages (321). Modest fertilization (and irrigation where possible) should help to rapidly establish stands. A fall/spring seeding at a rate of 10 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

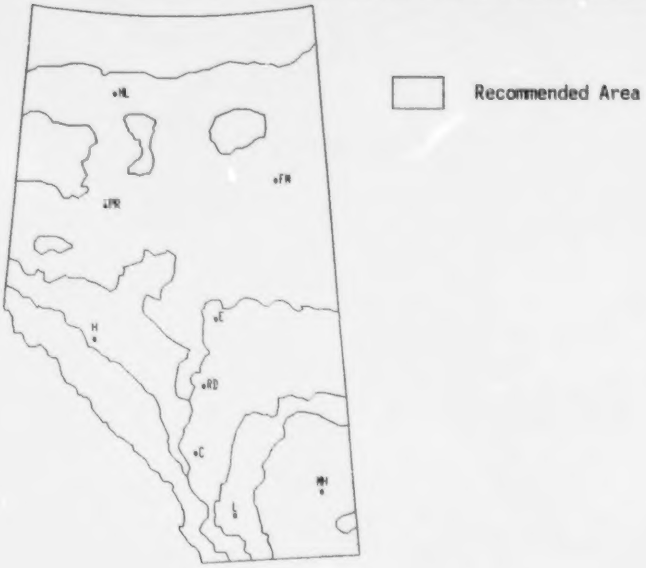
The species is well suited for native range, particularly where periodic flooding or poor drainage are expected (water collection areas), and where occasional drought may occur (179, 340). In Canada, Cominco has had encouraging experimental results with western wheatgrass on low pH gypsum waste ameliorated with lime (to pH 6.0), and directly on saline/alkaline tailings from their Yellowknife gold operation (163). When seeded on reclaimed coal strip mined areas, "Walsh" showed better establishment and persistence than the other wheatgrasses or the wild ryes (717). Western wheatgrass has been planted with poor results on at least two southern interior B.C. metal mine sites (143). Limited success has been encountered at Tent Mountain as indicated by fifth year survival and production data (723).

In the U.S., western wheatgrass is widely used for minesite reclamation in the arid Great Basin, intermountain region and prairie of the U.S. "Barton" and "Rosana" are predominantly range grasses, while "Arriba" is well adapted to soil stabilization and revegetation after disturbances (183, 321, 429). Use noted (often "Barton") at the Bridger Coal mine (Montana), Knife River Coal Co. mines at Beulah and Gascoyne (N. Dakota), Wyodak Resources mine (Wyoming), Amax Coal Co. mine at Belle Ayr (Wyoming), Pacific Power and Light Glenrock mine (Wyoming), Decker mine (Montana), Baukal-Noonan Centre mine (N. Dakota) and FMC Carter mine (Montana) (90, 328). About 70% of mines in the Northern Great Plains Coal Province seed western wheatgrass (31). Plug transplants were successful in the face of drought when planted on raw coal mine spoil at the McKinlay mine, in New Mexico (80).

Main assets of the species include an aggressive sodforming habit, tolerance of prolonged flooding and of saline conditions, and moderate drought tolerance. Western wheatgrass is not a strongly superior forage species however, and has only moderate tolerance to grazing. It is also relatively slow to establish and is most vulnerable at that time.

Agropyron spicatum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance				X	
pH Tolerance Acid				X	
Base			X		
Winter Hardiness			X	X	
Erosion Control	X				
Persistence		X			
Palatability		X			
Browse Tolerance				X	
Moisture Preference	Moist to dry.				
Soil Preference	Well drained, tolerates wide textural range.				

Agropyron spicatum (Pursh) Scribn. and Smith

SPECIES BIOLOGY

Taxonomy

Bluebunch Wheatgrass var. Beardless Bluebunch Wheatgrass (430).

Also *A. spicatum* var. *inerme* Heller.

Origin and Range

Native to western North America (214, 199, 340). Ranges from Alaska through the interior of British Columbia, east through Alberta to Michigan, and from the Dakotas south to Texas, and including American states westward.

Growth Habit

Plants densely tufted, often forming large bunches (47). Tall or intermediate height (60 to 100 cm) (424, 199). Fibrous root system (47), but with short rhizomes (183). *A. spicatum* displays awned seeds, while *A. spicatum* var. *inerme* is the awnless variety (199, 340, 179, 183). Variable ecotypes have been recognized (179).

Nitrogen Fixing - None

Longevity

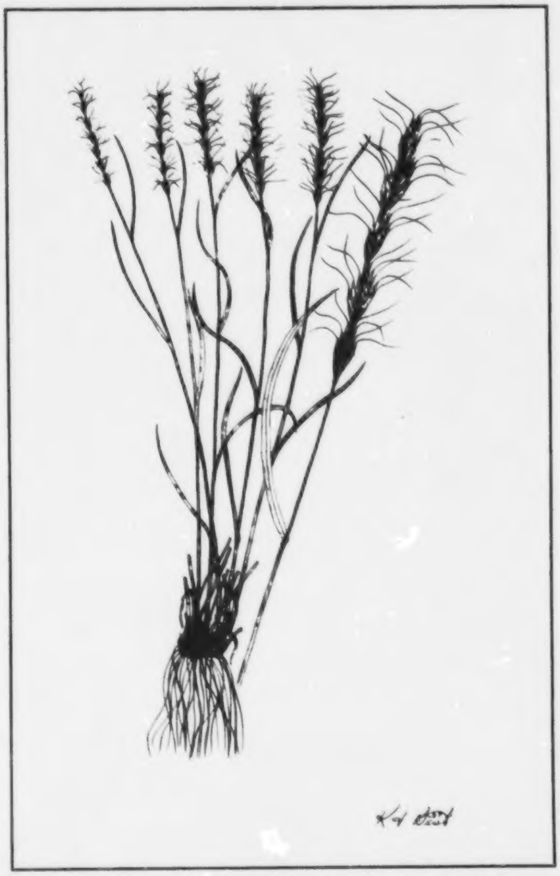
Long-lived, cool season (639) perennial. Winter hardiness is rated from very poor (D. Walker, pers.comm.) to good (183). Growth rate is only moderate (338).

Self Propagation

Seeds large and heavy. Production high (183). Establishment by natural reseeding is moderate (338). Though stands do spread slowly from short rhizomes (183), vegetative reproduction is considered poor (338).

Ecological Setting

Native to drier areas such as the southern Canadian prairies, B.C. interior, and U.S. intermountain region (183, 199, 47). Common on dry slopes, canyons, dry open woods and plains (199). Also common in river valleys in Alaska (214). Though total precipitation in the order of 20 to 35 cm is satisfactory (639), growth is better above 25 cm annually (183, 340). A small form identified as *A. vaseyi* occurs in the deserts of the American Great Basin (199). Though the species will grow at higher elevations, forage production is much lower (340).



TOLERANCES

Soil Preferences

Prefers well drained soils (489) which in Alberta and elsewhere would include Chernozems and Brunisols, particularly brown soils (179). Amount of soil moisture retained at depth is important for perpetuating established stands (93). Range of suitable textural classes is apparently broad, though it is considered best on medium to clayey soils (639).

Nutrient Requirements

Noted to be persistent under adverse conditions (183), presumably including fairly low nutrient levels.

Soil Reaction

Somewhat more tolerant of alkaline than acid conditions (338). Apparently not adapted to extremes.

Soil Salinity

Only fair tolerance to saline conditions (424).

Drought

Highly drought resistant, especially in well established stands where roots penetrate into deep soil layers (183, 93, 179). Amongst the wheatgrasses, it is exceeded in drought tolerance only by crested wheatgrass (Agropyron cristatum), and possibly streambank wheatgrass (A. riparium) (340).

Heavy Metals and Hydrocarbons

No particular tolerances noted from the literature.

Shade - Only slightly shade tolerant (340).

Grazing or Mowing Tolerance

Inferior to other adapted grasses in grazing tolerance (340). Even light grazing or mowing reduces plant size (114), vigour (314) and cover (287). Heavy grazing has greater impact. Recovery is possible if grazing (or mowing) is discontinued and competition is suppressed (287, 313). A rotational-deferred system of grazing is the best practice; not more than 50% of the current year's growth of stems and leaves should be taken. Three years protection after seeding is recommended (179).

Susceptibility to Disease and Insect Damage

Seed should be treated with an insecticide to prevent wireworm damage (340). Also susceptible to the soil-borne pathogen Podosporiella verticillata; Seed should be treated with a fungicide (340). Injured less by ground squirrels than crested wheatgrass (A. cristatum) (179).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Root production, at least by the A. inerme variety, is very high (179). Root production over six growing seasons has been measured as almost 25% higher than that of crested wheatgrass (179). Soil stabilization ability is very high (338). The occurrence of bluebunch wheatgrass on dry slopes and in canyons attests to its usefulness for erodible slopes (183, 119, 214). The root systems exploit deep soil water through the summer months, consequently soil moisture is likely to be substantially depleted by October (93).

Adaptation to Disturbance

Considered only moderate, and poorer than all other wheatgrasses (338).

Competitive Ability

Natural competition severely restricts the growth and vigour of bluebunch wheatgrass (313). This plus susceptibility to grazing pressure lead to the recommended practice of planting in pure stands (340).

Commercial Value

Valuable as a native range grass where its palatability and drought resistance are important (183).

Palatability and Nutritive Value

Palatability is considered high (427). Though reducing size of plants, even light grazing improves nutrient content (114) by increasing proportion of leaves above ground. Even when well headed, the coefficient of digestibility is higher than for similar crested wheatgrass stands (179). Retains feed value and palatability late into summer and fall (183).

Seed or Planting Stock Availability

A. spicatum var. inerme is available in the United States under the cultivar name "Whitmar" (Reg. No. 4). "Secar" is also available in the US (639). Other cultivars not available, but undergoing testing, include "P-739" and "P-6409". "P-739" is somewhat better adapted to moister conditions and higher elevations. "P-6409" is smaller, adapted to droughtier conditions and is more persistent under adverse conditions (183). Considerable variation exists between strains and ecotypes (340). No licensed cultivars are available in Canada (138). Approximately 140 000 seeds/lb (639).

Methods and Ease of Establishment

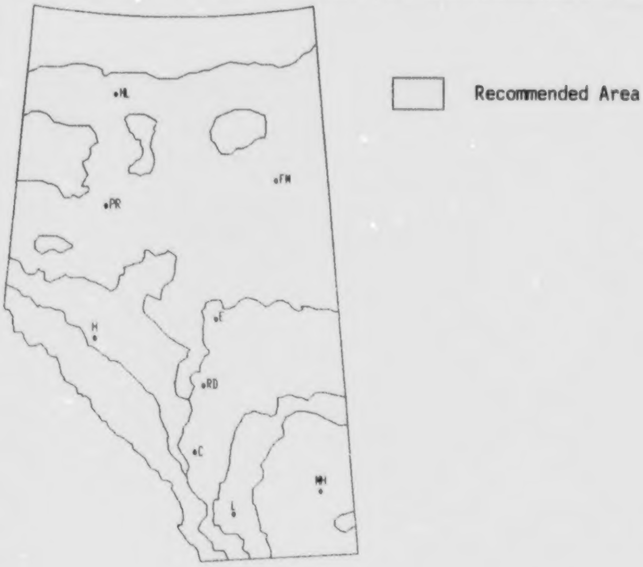
Ease of establishment by seeding or transplanting is considered good (338). Seed of the awned ecotypes must be processed before they can be cleaned and planted. When seeding "Whitmar", good stands are obtained from spring seeding on well prepared (or summer fallowed) seedbeds; when preparation has been less extensive, fall seeding is recommended. Pretreating with insecticides and fungicides should be considered. Deep furrow drills are preferred to other seeders. Grass requires three years of protection prior to grazing (179). Planting in pure stands is recommended to avoid overgrazing, allows grazing rotation, and presents forage to livestock in as palatable a form as possible (340). Seed shatters readily. Binding or swathing in the soft-dough stage is preferable to combining. Germination remains above 70% during six years of cool, dry warehouse storage(179). A fall/spring seeding at a rate of 6 to 8 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

Bluebunch wheatgrass and beardless wheatgrass are widely used native grasses, particularly in the interior of British Columbia (114) and in the dry intermountain region of the United States (183, 340, 179). They are favored for their palatability and drought tolerance, though they are not especially good competitors, nor do they withstand heavy grazing pressure. The species has apparently been used for reclamation (34) in B.C., and has survived after two years on plots at Luscar, Alberta (259). The history of test plot and operational trial data is sparser than for most other wheatgrasses. It has undergone genetic testing on the Alberta east slopes (455, 453).

Agropyron subsecundum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance			X	X	
pH Tolerance Acid				X	
pH Tolerance Base			X		
Winter Hardiness		X	X		
Erosion Control		X			
Persistence			X		
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Moist to dry.				
Soil Preference	Well drained.				

Agropyron subsecundum (Link) Hitchc.

SPECIES BIOLOGY

Taxonomy - Awned Wheatgrass

Also Agropyron trachycaulum (Link) Malte var. unilaterale (Cass.) Malte.

Origin and Range

Native to North America. Range extends from Alaska to Labrador; northern extent is about the limit of the open boreal forest (214). Distributed south to New England and along a line linking West Virginia, Missouri, New Mexico and California. Range is very similar to A. trachycaulum (199).

Growth Habit

An erect, loosely tufted bunchgrass ranging from 50 to 100 cm in height (199). Fibrous root system (47); without creeping rhizomes (199). Not domesticated (179).

Nitrogen Fixing - None

Longevity

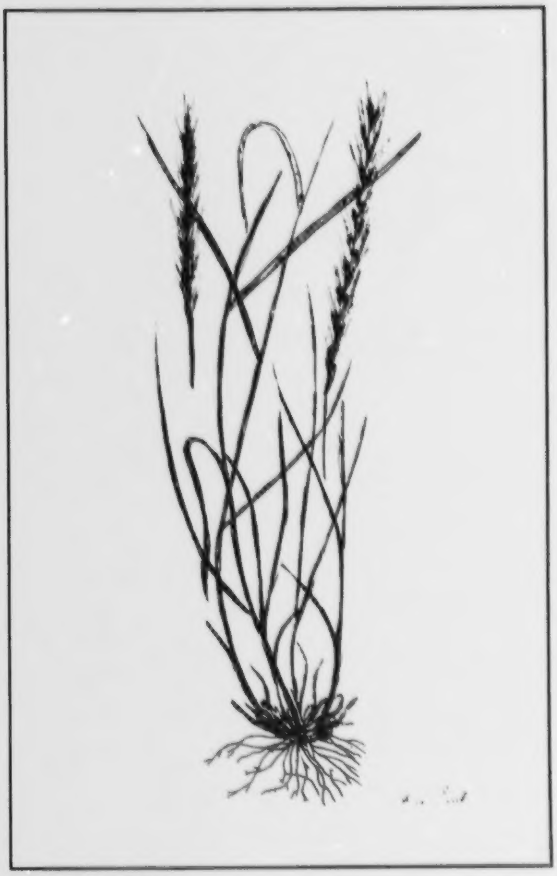
Short-lived perennial, though living generally longer than A. trachycaulum (179).

Self Propagation

Strong reseeder (340), usually setting seed the first year (179). Produces tillers, but in less abundance than slender wheatgrass (A. trachycaulum) (450). Seedling vigour is excellent (179). At least one ecotype, a USDA accession (P-9115), produces more seed than "Primar" slender wheatgrass (179).

Ecological Setting

Common in fairly moist meadows and open woods (199) and along forest margins (47). Optimal precipitation level seems to be about 35 cm per year. Though the species does well throughout the forested mountain areas, only adapted breeds and subspecies will be successful in the high sub-alpine or alpine (340). Plants collected on Kootenay Plains (2 375 m ASL) (379), and Pigeon Mountain (1 830 m ASL) (450). Good plot trial yields were found at Cadomin (1 675 m ASL) (364).



TOLERANCES

Soil Preferences

Like A. trachycaulum, it prefers moist to dry soils that are well drained (179). Most common on Chernozemic soils, but occurs on well drained Luvisols and Brunisols as well (179). Fares better on mineral soils than on raw overburden (364).

Nutrient Requirements

Often occurs naturally under conditions of relatively low nutrient supply, though better conditions are probably favored.

Soil Reaction

Somewhat more tolerant of alkaline than of acid conditions (338).

Soil Salinity

Presumably somewhat tolerant of moderate or low salinity.

Drought

Somewhat more drought tolerant than A. trachycaulum (340).

Heavy Metals and Hydrocarbons

No specific heavy metal or hydrocarbon tolerances noted.

Shade

Noted to be relatively shade tolerant (340).

Grazing or Mowing

Tolerance to grazing is not known, but may be comparable to A. trachycaulum.

Susceptibility to Disease and Insect Damage

Resistant to stripe rust (179), otherwise not known.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

A good soil stabilizer (338) and, as with most grasses, contributes significant biomass for soil building. Its rapid establishment and high emergence success suggests that it would be a good species for erosion control purposes; better soil stabilization abilities than A. trachycaulum (338).

Adaptation to Disturbance

Reasonably well adapted to disturbance (338).

Competitive Ability

Due to its early vigour and rapid establishment, considered a good early competitor (179). Considered aggressive (340). As with certain other wheatgrasses, it apparently fares better competitively with low rates of fertilization (404).

Commercial Value

Improved and unimproved domestic pasture, wildlife range and short term erosion control (340, 338, 144).

Palatability and Nutritive Value

Considered moderately palatable on Colorado ranges between 2 000 and 2 700 m ASL (427). High palatability for bighorn sheep and elk, moderate for moose and low for deer (144).

Seed or Planting Stock Availability

Commercial cultivars apparently nonexistent. Available commercially, but no named cultivars (106). High elevation strains not commercially available, but readily harvested and propagated from native stands (340). Typical genetic variability indicates advisability of local collections where possible (179).

Methods and Ease of Establishment

Establishment methods the same as A. trachycaulum, except slightly less readily transplantable (though still good) (338). Must be processed to remove short, straight awns prior to drilling (340, 179).

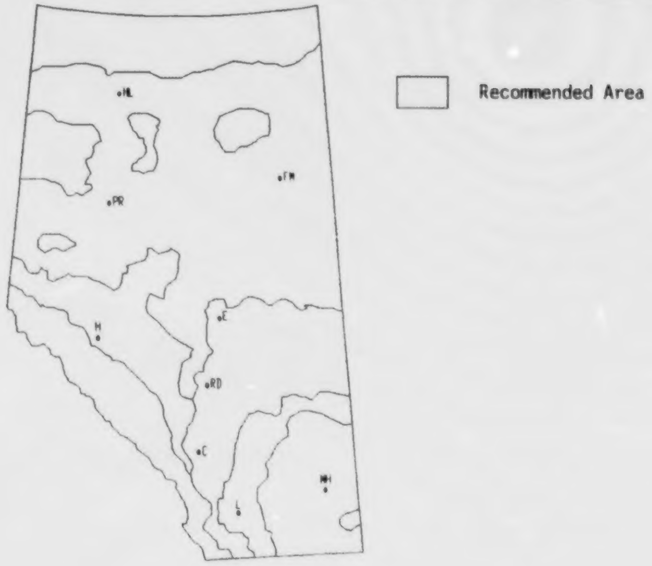
Current Status for Reclamation

The species has undergone study for genetic improvement and propagation (450, 453) and for operational field use. It was among the best grasses for subalpine sites in five years of testing on overburden and topsoil at Cadomin (740) and Tent Mountain and was recommended for use in the eastern slopes region (723). At Fort McMurray it performed moderately well in five years of testing on amended tailings sand (705).

Probably because the species is a native, and since commercial seed is scarce (and/or expensive), little use has apparently been made of it on large scale studies or operations. Also, since the species displays most of the same characteristics as A. trachycaulum, but is generally less tolerant of extreme soil conditions (except for superior drought tolerance), less well known, and less readily available, it is being neglected in favor of the closely related slender wheatgrass.

Agropyron trachycaulum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance		X	X		
pH Tolerance Acid					
pH Tolerance Base		8.8			
Winter Hardiness		X			
Erosion Control		X			
Persistence			X		
Palatability			X		
Browse Tolerance		X			
Moisture Preference	Moist to dry.				
Soil Preference	Medium texture, well drained.				

Agropyron trachycaulum (Link) Malte

SPECIES BIOLOGY

Taxonomy - Slender Wheatgrass

Also A. trachycaulum var. unilateral (Cassidy) Malte, var. glaucum (Pease & Moore) Malte, and var. trachycaulum (690). Also A. pauciflorum, (Schwein) Hitchc. (214).

Produces hybrids with Hordeum jubatum L. (x Agrohordeum macounii (Vasey) Lepage), Elymus innovatus Beal (x Argroelymus hirtiflorus (A.S. Hitchc.) Bowden), and possible Elymus canadensis L. (x Argroelymus mossii Lepage) (690).

Origins and Range

Native to North America, not generally occurring elsewhere (214). Range extends from Labrador to Alaska, south to New Mexico, Missouri and West Virginia. Also in western Mexico (199).

Growth Habit

A tufted bunchgrass ranging in height from 50 to 100 cm (341). Cultivated heights are typically 90 cm erect or somewhat erect at the base. Very short rhizomes are common (47) though the species is considered a domesticated bunchgrass (41, 179).

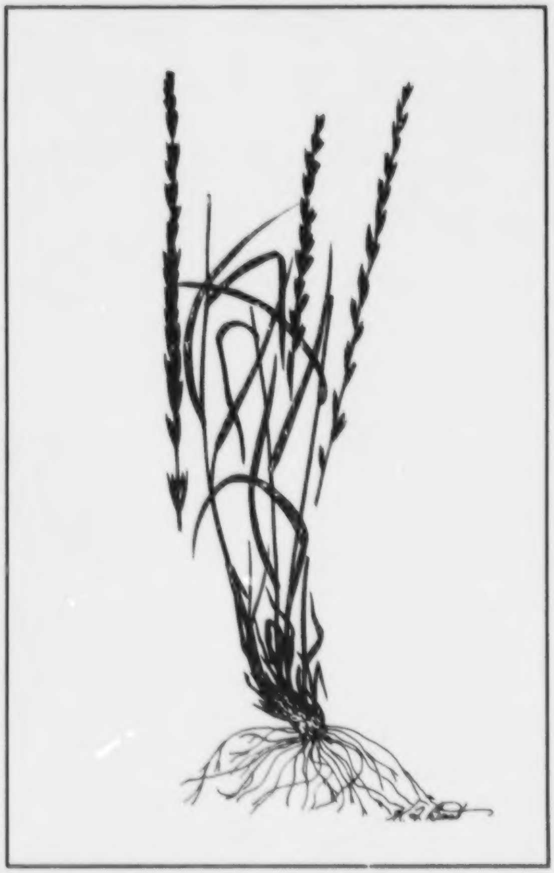
Nitrogen Fixing - None.

Longevity

A relatively short lived, cool season (639) perennial species (391, 183, 331) that depends on reseeding to perpetuate a stand (640). Native in the subalpine though stands from commercial seed sources will not set seed at high elevations. Seed from local, subalpine collections may result in stands lasting up to 10 years, with good reseeding (41).

Self propagation

This species is somewhat rhizomatous (47) and produces considerable productive tillers (450). It is a self-pollinating species (700) noted for its high production of seed (450, 340) though not for its vegetative reproduction (338). Seed is relatively easy to thresh and handle (640). Considerable variation has been noted amongst northern ecotypes in both vegetative growth and seed production (700). Seed yield is somewhat higher in the cultivar "Revenue". Seed of the "Primar" cultivar retained 70% viability over 6 years under cool, dry warehouse storage (179). Seeds display high germination rates and seedlings are vigorous. (391, 183, 340). Commercial cultivars may not set seed at higher elevations (41).



Ecological Setting

A common species in moist and semi-arid ranges of the United States and Canada (199). Common to open woods, boreal forest to subalpine and subarctic (214,341, 47, 312, 41). Component of saline tall grass prairie (729, 730). With such a wide range of adaptability it must have a great number of ecotypes within its population (700). Requires a minimum of 40 cm of precipitation (639). Where plants occur in the high subalpine, specimens are shorter and denser (199). In Alberta, plant and seed collections have been made at elevations of 1830 m ASL (Savanna Creek, Pigeon Mountain) and 2600 m ASL (Ram Mountain) (456). Invasions in BC at elevations of 2200 m ASL (494) have been noted. In Utah, the species is native to areas at 2800 m ASL (106). Noted to have good winter hardiness (240).

TOLERANCES

Soil Preferences

The species prefers moist to dry sites (12). Medium textured and well drained soils of the Chernozemic, Solonetzic, Luvisolic and Brunisolic Orders are preferred (179). Requires good soil drainage for survival (609).

Nutrient Requirements

The species occurs naturally under a variety of nutrient conditions. In reclamation situations it is normally fertilized or grown in combination with legumes (422). In a hydroponic study it was severely affected by N, P, and K treatments, with plants being most sensitive to K deficiency. Characteristic deficiency symptoms are as follows:

Nitrogen: Progressive fading of the leaves resulting in dusky brown color followed by tip dying; restricted growth rate leading to very small, tillerless plants.

Phosphorus: Spindly growth; purple pigmentation on older leaves; younger leaves dark green; restricted growth.

Potassium: Extremely reduced plant growth; progressive leaf scorching starting from tips and spreading towards leaf base; the scorched areas of leaves turn ash-white and papery and finally drop off.

Iron: Yellowing and chlorosis of youngest leaves, followed by chlorosis of almost all the leaves except the oldest; growth of plants slightly restricted.

Slender wheatgrass has a low requirement for Zn, (710). It performs best on tailings sand dykes at relatively lower fertilization rates, possibly because of poorer success of other species, and reduced competition (359).

Soil Reaction

Considered moderately to highly tolerant of alkaline soil conditions (391, 183). Successful on coarse textured overburden (pH 8.8) at Cadomin (364), though not successful on an alkaline tailings pond (pH 9.0) at an asbestos mine in Quebec (where heavy metals may have also been a problem) (310).

Soil Salinity

Displays moderate to high tolerance to soil salinity (85, 422, 426). Various tolerance ranges are quoted in the literature: 11 to 16 mS/cm (468) and 8 to 15 mS/cm (247). Established readily on a moderately saline clay with electrical conductivity (EC) values ranging from 9 to 21 mS/cm (717). Moderate growth has been demonstrated in the Alberta oil sands at about 12 mS/cm, though vigour was somewhat reduced (404). In a greenhouse study herbage yield started to decline on soils with EC values greater than 10 mS/cm, with 50% reduction at EC values about 16 mS/cm. Slender wheatgrass was more tolerant than brome grass and reed canary grass but less tolerant than Russian wild ryegrass, Altai wild ryegrass and tall wheatgrass. Slender wheatgrass salinity tolerance varied with growth stage with germination being the most sensitive (687). Some ecotypes are more salt tolerant than others.

Drought

Found on relatively moist sites on semi-arid western rangelands (736); considered mesic species. Based on subjective field observations and measurement of turgor pressure responses considered to have low drought resistance (664). Requires the equivalent of 35 cm of precipitation annually (391, 178, 183, 426) depending on evapotranspiration. Matures later than certain other wheatgrasses, and therefore is more susceptible to the effects of drought (391). Relatively less drought tolerant than crested wheatgrass (391).

Heavy Metals and Hydrocarbons

The species appears to do acceptably well where boron concentrations are moderately toxic (10 to 22 ppm) (305). Unsuccessful on alkaline tailings characterized by heavy metal problems (310). There is some evidence to indicate that this species performs satisfactorily on heavy and lean bitumen contaminated materials (404). No other special tolerances have been noted from the literature.

Shade

Presumably reasonably shade tolerant since its habitat preferences are similar to the shade tolerant A. subsecundum (304).

Grazing or Mowing

Moderately tolerant to grazing and mowing (P. King, pers. comm.). Reported sharp decrease in cover (most prevalent species to least prevalent) under grazing (734).

Susceptibility to Disease and Insect Damage

Moderately resistant to disease and insects (339). Resistant to leaf and stem rust and stripe rust, and with varying resistance to head smut (183, 179, 618). Occasionally attacked by powdery mildew (35). Somewhat tolerant to grass bug (*Labops hesperius*) in nursery trials, possible use in reseeding semi-arid rangeland where grass bugs are a problem (658). However, slender wheatgrass was found to be susceptible to grass bugs compared to native grasses in a field trial in Utah (658). Appears to be less heavily grazed by voles and mice than many other native pasture species (111).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Because of its rapid establishment, high emergence success and rapid spreading ability, the species is a good choice for use in a short-term erosion control program (187, 340). A moderately good soil stabilizer (338). Possesses a relatively inextensive root system. When used with long lived or slower developing species, it is at first more prominent, but eventually becomes secondary (187). Its high biomass production indicates good soil building potential. The species is often recommended for use on steep slopes, especially in cooler locations (249, 422).

Adaptations to Disturbance

Good colonizer, reasonably well adapted to disturbance (338), often filling in sites where sod has been opened by rodent activity or other disturbance (340). Has been recorded as colonizing various disturbed sites in Alberta, including a droughty exposed site in Jasper National Park (651), a scarified gravel road bed in Banff National Park (652) and abandoned coal mine spoils in the eastern slopes (708).

Competitive Ability

A relatively good competitor in the first two or three years because of its rapid establishment and early seed production (339). Less competitive than pubescent wheatgrass but more competitive than slower developing Russian Wild ryegrass, crested wheatgrass and Altai wild ryegrass in greenhouse trials (715). When planted with crested wheatgrass declined from 69.5% to 2.6% of herbage production after 4 years. When planted in mixture with crested wheatgrass, thickspike wheatgrass, western wheatgrass and green needlegrass; slender wheatgrass was eliminated after 4 years (711).

Commercial Value

Suitable for hay and forage production under conditions of natural rainfall (674), partly because of its superior biomass production (187). Wildlife range and short term erosion control (12, 144, 391, 340, 179).

Palatability and Nutritive Value

Considered a good quality hay crop species and a fair pasture plant (391, 183). Fairly palatable (614). Cattle grazed Altai or Russian wild ryegrass but refused to eat slender wheatgrass grown in association with it (662). Among the preferred foods of bighorn sheep and elk, and of moderate palatability to moose (144). Moderately to highly palatable on Colorado ranges above 2000 m ASL (427).

Seed or Planting Stock Availability

At least two commercial cultivars "Primar" and "Revenue" are licenced and available in Canada (138). Revenue has superior establishment ability, salinity tolerance, forage quality and yield compared to Primar (618). "San Luis" is available in the US (639). Native seed is fairly easily collected since seeds are large and the species is common. Because of considerable genetic variability, it is important to collect seed from appropriately adapted local populations (456). Limited quantities of seed of a cultivar adapted to northern conditions may be available from fall 1991 (M. Vaartnou pers. comm). Five lines of slender wheatgrass are presently being tested for potential use in alpine reclamation with the objective of registering successful lines as commercial seed (655). Approximately 159 000 seeds/lb (639).

Methods and Ease of Establishment

Early summer seeding is better than midsummer or fall (655). Fall seeding has also been recommended at a rate of 6 to 8 lbs PLS/ac (639). Slender wheatgrass has excellent seedling vigour and is very productive for the first 1 or 2 years after seeding (616). Adapted to seeding in combination with other pasture grasses and legumes (391), notably with sweet clover (*Melilotus* spp.) on saline sites (183). Seed mixes containing longer-living, slower establishing and/or earlier ripening species are recommended (187, 340). Fertilization at time of planting would likely be advantageous. Topdressing of coaly or contaminated wastes prior to seeding is usually adequate to ensure high rates of emergence (187, 364, 489). Yields are notably higher under relatively dry range conditions, when irrigation is possible. Slender wheatgrass is rated as high for both seed and transplanting establishment (338).

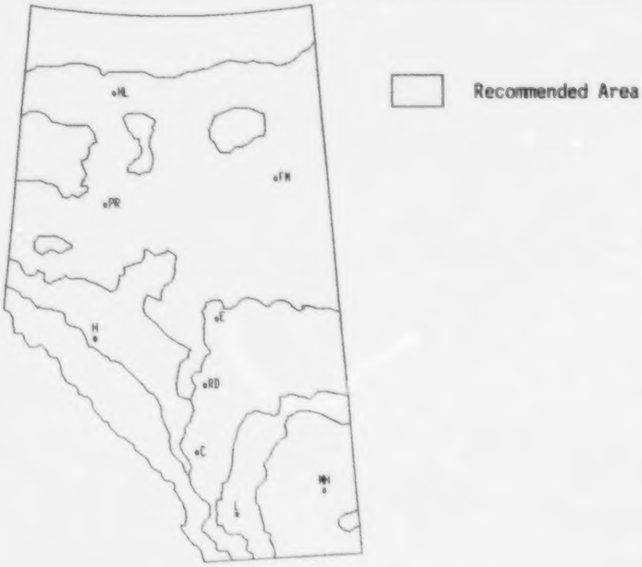
Current Status for Reclamation

A widely used range and forage species (391) in agricultural and semi-agricultural situations. "Revenue" particularly suitable cultivar for saline soils and short rotations in the Dark Brown, Black, and Eluviated Black soils of Western Canada. Extensive testing over five years along the Eastern Slopes Region (705, 723, 732, 740). Determined that the native species and the cultivar "Revenue" are well suited to the subalpine region on topsoil sites and overburden sites with fertilizer, however, reproduction of "Revenue" was lower that of the native species (740). Native and "Revenue" slender wheatgrass produced good ground cover but failed to set seed in the alpine (740). "Revenue" also performed well in mixed seedings on various terrain on a pipeline right-of-way in the upper MacKenzie Region of the Boreal Forest from Norman Wells, N.W.T., to Zama, Alberta (644) but was short-lived (three years) in tests in arctic tundra in the Mackenzie River Delta. The native species were best species in five years at tests at Fort McMurray on tailings sand (705) but died out after eight years in a grass/legume mixture on similar soils (643). "Revenue" also did poorly in grass/legume test mixes in overburden and topsoil sites at the Judy Creek test mine (646).

Major assets of slender wheatgrass are its tolerance to both highly saline and moderately alkaline soils, its relative ease of establishment, its high biomass production, its colonizing characteristics, its rapid addition of organic matter to disturbed soil and its superior self-propagation success.

Agropyron trichophorum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance			X		
pH Tolerance Acid			X	X	
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence		X	X		
Palatability			X		
Browse Tolerance		X	X		
Moisture Preference	Moist to dry.				
Soil Preference	Relatively sandy to clay well drained.				

Agropyron trichophorum (Link) Richt.

SPECIES BIOLOGY

Taxonomy - Pubescent Wheatgrass

Origin and Range

Introduced from the USSR and eastern Europe (183, 430, 340). Planted in the northwestern U.S. (199) and in western Canada, generally below arctic and alpine treelines.

Growth Habit

A tall, erect sod-forming grass (183, 47), up to 110 cm in height depending on site conditions (139). Heights of 75 cm are common in Colorado (424). Somewhat rhizomatous (391, 232, 47).

Nitrogen Fixing - None

Longevity

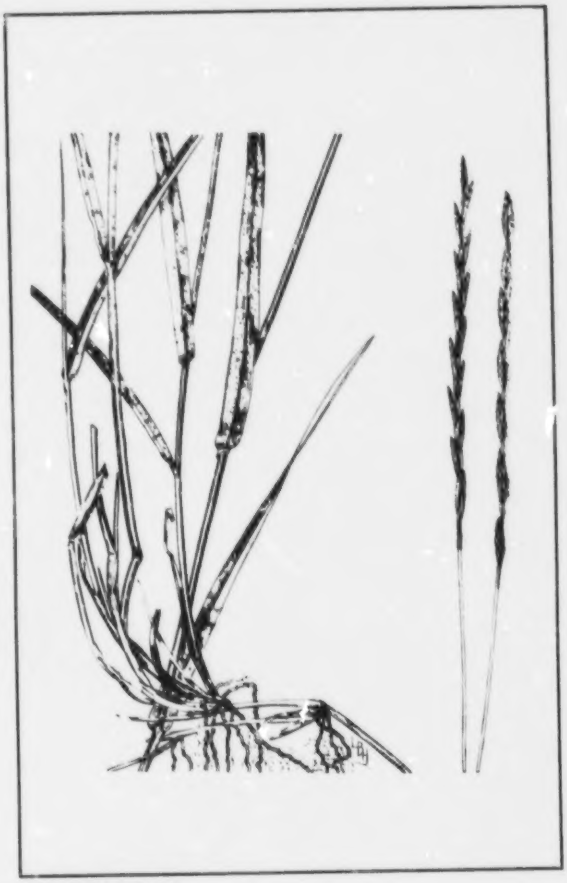
Long-lived, cool season (639) perennial (391, 426, 179). On dryland, plants may lose vigour after 3 to 5 years, with a resultant drop off in production (391). Has good overall hardiness (139).

Self Propagation

The species reproduces itself both by seeding and vegetatively through a spreading root system (391, 183, 340). Natural reseeding ability is rated as medium, while natural vegetative reproduction is considered very good (338). Seed yield is moderate to good (139). Good establishment (179); very good growth rate (338). Seeds are large and seedling vigour is excellent (179, 320).

Ecological Setting

Habitats are nearly the same as for A. intermedium. Found fairly commonly in hayfields and pastures in the parkland areas (47). Also found in dry, open habitats (338). About 30 to 35 cm (639) of precipitation is required at lower elevations or where evapotranspiration is relatively high; at lower rates of evapotranspiration, 25 cm is adequate (179). The "Topar" and "Luna" cultivars are adapted to shallow, low fertility soils, and require 25 to 35 cm of precipitation (183, 320). "Trigo" cultivar has been successful in trials where precipitation was as low as 15 cm annually (183). "Luna" has reduced seed production at annual precipitation below 45 cm (320).



TOLERANCES

Soil Preferences

Prefers well drained (179, 639) but moist soils (12, 249). Also achieves good growth under low soil moisture conditions (422). Chernozems, Brunisols, well drained Podzols and Regosols are all suitable substrata. A wide variety of textural classes are suitable, from relatively sandy to fairly clayey (426). Performance of pubescent wheatgrass (cultivars not specified) seeded on waste rock and overburden at several metal mining operations in the southern interior of B.C. was rated as "moderate" (143).

Nutrient Requirements

Under low fertility conditions, pubescent wheatgrass may become sodbound after 4 to 5 years, resulting in greatly reduced production (340). "Luna" and "Topar" cultivars withstand lower fertility (183, 320). Will be successful under conditions of lower fertility than intermediate wheatgrass (426). Like slender wheatgrass (Agropyron trachycaulum), it is one of the better companions of legumes at lower fertilization rates (359).

Soil Reaction

Prefers mildly acid, neutral or mildly alkaline conditions (179). Possibly favoring mildly alkaline conditions (338). Withstands more alkaline conditions than intermediate wheatgrass (426).

Soil Salinity

Fairly tolerant of soil salinity (183, 424), especially the "Greenleaf" cultivar. Rated as having moderate tolerance in the range of 4 to 8 mS/cm (247). Seeding and planting recommendations in Montana, however, indicate that the species is poorly adapted to saline and alkaline sites (422).

Drought

Somewhat more drought tolerant than intermediate wheatgrass (A. intermedium) (391, 183, 426), but less drought tolerant than crested wheatgrass (A. cristatum) (340). Performed very well under dry non-irrigated conditions in Texas (375). Becomes dormant during periods of drought, reviving with the rains. Prefers sites where significant annual moisture is derived from snow (320).

Heavy Metals and Hydrocarbons

Considered intolerant to boron (5 ppm) when grown directly on spoil materials in California (344).

Shade

Not very well adapted to shady situations (340).

Grazing or Mowing

Good persistence under close grazing is attributable to its sod-forming habit (340).

Susceptibility to Disease and Insect Damage

The species is relatively free of disease (179). Readily infected with leaf blight, causing foliage to become dry and unpalatable (340). Subject to Banks grass mite (Oligonychus pratensis Banks), which feeds on leaves; timely application of dusting sulphur or other miticides is effective. Damage is usually not severe in grazed stands. Infestations of Pacific grass bug, which feed on leaf chlorophyll, are generally not serious enough to warrant treatment (179).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Considered a very good soil stabilizer (338) because of its sod-forming habit. Stands spread rapidly (183, 340) amidst other species.

Adaptation to Disturbance

Well adapted to disturbance (338).

Competitive Ability

Generally a good competitor, spreading rapidly by vegetative means (183). In Nevada, it displayed a rare ability to aggressively invade stands of big sagebrush and wheatgrass (Bromus tectorum), an aggressive, weedy annual range grass (183, 308).

Commercial Value

Can be used for hay or pasture, although its ability to stay green over summer, when moisture supplies are low, suggests that it is an especially good pasture species (391). Also suitable for erosion control (422).

Palatability and Nutritive Value

More palatable after heading than crested wheatgrass (340). Herbage yield is moderate to high (139). As with other wheatgrasses, highly palatable for bighorn sheep and elk, moderate for moose, but not often used by deer (144). Found to have moderate palatability for a wide range of site conditions (moisture, climate, elevation) (427). Considered to have good forage value for cattle (320, 19).

Seed or Planting Stock Availability

Several commercial cultivars are available. "Greenleaf" was developed in Canada at Lethbridge and it is the only cultivar licensed in Canada. "Luna" (Reg. No. 6), "Mandan" and "Topar" are available in the US (639). Other cultivars are still undergoing testing ("Mandan 759" and "Trigo") (183). Local seed collection is relatively easy due to large seed size and general abundance of seed (179). Since seed does not shatter, the crop can be swathed and combined, but it is difficult to thresh because the rachis breaks up and the seeds adhere to segments (179). The rachis segments are difficult to remove when cleaning the seed; therefore the maximum purity of seed is less than 90% (179). Approximately 100 000 seeds/lb (639).

Methods and Ease of Establishment

Deep furrow drills are preferred for seeding; the species can be planted in fall (639) or in spring with equally good results (179), presumably due to its tolerance of later summer drought. Can be grown alone or in mixtures including legumes (179). An initial fertilization may be useful, but otherwise stands will do acceptably well under minimal soil fertility conditions. The species does as well as any grass except creeping red fescue (Festuca rubra) and crested wheatgrass on waste rock and overburden in the southern interior of B.C. (143). A seeding rate of 10 to 12 lbs PLS/ac has been recommended (639).

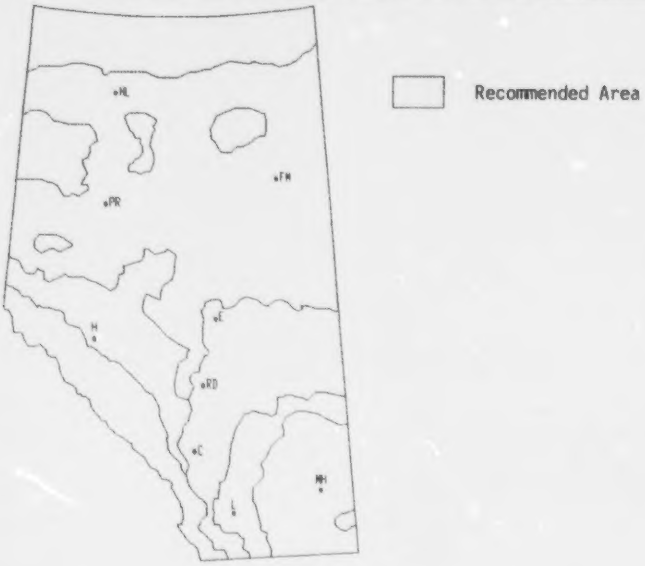
Current Status for Reclamation

A moderately well used hay and pasture species in western Canada and the northwestern U.S. (391, 199), since it remains green late in the season. Considered a good species for dry reclamation situations, though it may have some elevational limitations in Canada. Currently in use at five metal mines in southern B.C. (143). Performing satisfactorily on top dressed ash lagoons at Wabamum (305). Grew well in initial stages in Grande Cache (269). Showed good experimental survival at Luscar (259). Fair to good results for mine revegetation under a variety of conditions have been recorded (213, 117, 90). "Greenleaf" performed poorly at Fort McMurray on amended tailings sand, dying out in a grass/legume mix after three years (643).

Major assets are its good drought tolerance, superior forage value (especially in late summer), aggressive sod-forming habit for erosion control, relative vigour, ease of establishment, low nutrient requirements, and longevity. It appears not to have particular tolerances to extreme pH, high salinity, shade, heavy metals or hydrocarbons.

Agrostis alba

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No ___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance				X	
pH Tolerance Acid		4.5			
pH Tolerance Base				X	
Winter Hardiness		X	X		
Erosion Control			X		
Persistence		X			
Palatability			X	X	
Browse Tolerance			X		
Moisture Preference	Wet, withstands prolonged flooding.				
Soil Preference	Clay textured, poorly drained.				

Agrostis alba L.

SPECIES BIOLOGY

Taxonomy - Redtop (138, 47, 179).

Similar to A. stolonifera L.; also sometimes called A. palustris Huds.

Origin and Range

Introduced to North America, probably before 1750 (138). Native to Europe (47, 341, 138). The species is found in the U.S. throughout cooler parts, especially northeast and northcentral areas (183). It is well established wherever moisture supplies are adequate (138). Similarly in Canada, the species is associated with fairly moist forested or partly forested areas.

Growth Habit

A relatively low growing, erect species which spreads by shallow creeping rootstocks or rhizomes (38, 341, 47, 391). Can achieve heights of 100 to 150 cm (47, 341), but is more typically about 60 cm (424, 139). Rooting is shallow (138).

Nitrogen Fixing - None

Longevity

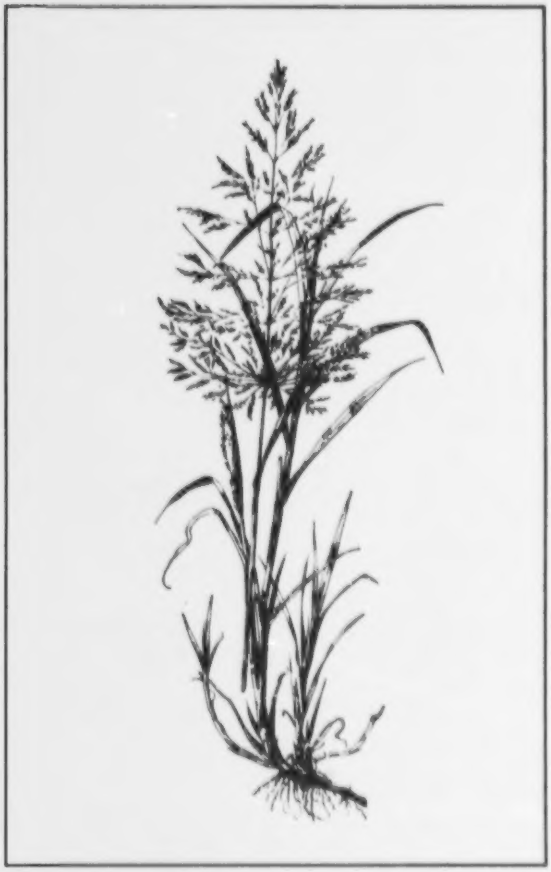
Long-lived, cool season (639) perennial (138). Only moderate winter hardiness (70, 139, 240), though in Alaska it is rated as high in this category (5).

Self Propagation

Seeds are small and generally numerous (138,257), though seed production is considered low in Alaska (5). Plants spread from shallow rhizomes (47). Growth is vigourous (391, 5).

Ecological Setting

Cultivated for meadows, pastures and lawns. Escaped throughout cooler, moister parts of North America (47). Also is found on roadsides and waste places (341). Prefers about 50 cm of precipitation annually (179, 639). Can be used with some success at elevations above about 1 500 or 1 600 m ASL (119, 70, 498), though success below treeline is sometimes better (70).



TOLERANCES

Soil Preferences

Adapted to poorly drained land, and clay soils (391, 183). High tolerance to wet soil and flooding, even over prolonged periods (5, 361).

Nutrient Requirements

Adapted to low fertility soils (179, 391, 361, 342) though best with moderate fertilizer application (5).

Soil Reaction

Adapted to neutral, acid or very acid soils (391, 183, 5, 179, 38). Good above pH 4.5 (346), though some records exist for occurrences below this level.

Soil Salinity

No more than low tolerance to saline soils (247, 361, 125), notably ones that do not exceed 4 mS/cm.

Drought

Redtop has some tolerance to drought (5, 138), especially when droughty periods are short (391, 179). Said to have poor resistance to drought in Alaska (5).

Heavy Metals and Hydrocarbons

Displays several-fold greater tolerance to aluminum than alfalfa (Medicago sativa) or timothy (Phleum pratense) (227). No particular success in revegetation of oil contaminated land (360).

Shade

Can be used for pasture and hay in timbered areas (179), therefore presumed to be at least moderately adapted to shade.

Grazing or Mowing

Recovery rate after cutting is moderate (5).

Susceptibility to Disease and Insect Damage

No information regarding disease or insect damage was located.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Strong rhizomatous habit (47) facilitates good erosion control characteristics. Widely used for erosion control and site stabilization (391, 183, 179). Commonly occurs on moist roadsides (9). May do well on slopes if moisture is adequate.

Adaptation to Disturbance

Redtop is known to colonize acid soils at Sudbury (476). Presumed to be well adapted to disturbance due to its strong sod-forming habit, abundant seed production, and preference for reestablishing on bare soil.

Competitive Ability

Relatively aggressive, though less so than timothy or colonial bentgrass (Agrostis tenuis) (183, 318, 138). Often grown with alsike clover (Trifolium hybridum) and timothy (179, 391). Fairly compatible with other species (5).

Commercial Value

Used for lawns, pastures, erosion control and occasionally for hay (183). Can be used along waterways, at waterline on irrigation ditches, on moist burned-over areas, or to retard invasion of weedy species (391, 179). Little value as a herbaceous species (138).

Palatability and Nutritive Value

Not as palatable as other wetland species (179, 391). Often considered to have poor palatability (5). Useful to wildlife for the cover, herbage and seed that it provides some species (346).

Seed or Planting Stock Availability

One cultivar, "Reton", has been identified, but it is no longer licensed in Canada, and seed supplies are short but "common" is available (138). Approximately 4 900 000 seeds/lb (639).

Methods and Ease of Establishment

Prefers shallow or broadcast seeding on prepared seedbeds or other bare mineral soil surfaces (179). Ease of establishment is considered good (424). Germination capacity is about 75% (257). A fall/spring seeding at a rate of 1 lb PLS/ac has been recommended (639).

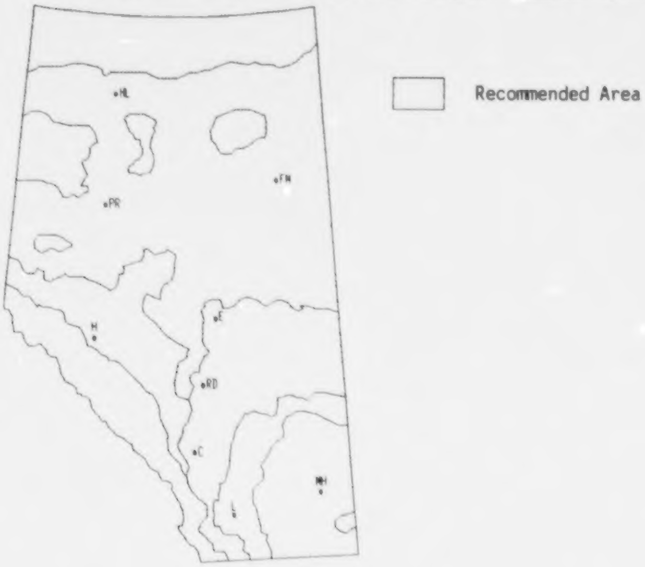
Current Status for Reclamation

In Alberta, redtop has been fairly widely tested and used for reclamation purposes. Early test results have been encouraging on various materials at Grande Cache (267), Luscar (259) and Tent Mountain (380, 723). In the oil sands area, redtop was among the most successful species on well drained, unimproved tailings sand (257), though certain subsequent trials have been less encouraging (359). In the B.C. interior, moderate success has been recorded on waste rock at two metal mines, but results on overburden and tailings have been poor (143). Redtop has been a volunteer on tailings pond remnants (96) in B.C. trials which are being actively carried out in the Northeast Coal Block (70), as well as in the south (164, 496). Many of these results are promising. Good overwintering was found at Yellowknife on moderately saline materials (457), as well as at Prudhoe Bay (284). While establishment was rapid it did not overwinter on the arctic coastal plain, however, it has persisted well for ten years in a mixed seeding in the Upper Mackenzie Region of the boreal forest on a pipeline right-of-way at latitude 65° N (644). Encouraging success on acidic materials has been recorded for Elliott Lake, Sudbury (476, 318, 316) and at Timmins, Ontario (408). Success has also been recorded on acidic tailings in Quebec (408) and New Brunswick (2). Success in the United States appears to be somewhat dependent on the moisture available at the reclamation site (16, 275, 342, 213, 212).

Major assets include its tolerances of flooding, acidity, certain heavy metals and low fertility levels; its erosion control capability, and its excellent establishment potentials. However, it is not highly palatable, not particularly drought tolerant, and may be somewhat lacking in winter hardiness.

Agrostis scabra

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid		4.0			
pH Tolerance Base					
Winter Hardiness	X				
Erosion Control		X			
Persistence				X	
Palatability					
Browse Tolerance			X		
Moisture Preference	Moist to dry.				
Soil Preference	Fine to sandy textured; well to imperfectly drained				

Agrostis scabra Wild.

SPECIES BIOLOGY

Taxonomy

Hair Grass; Tickle Grass (312); Rough Hair Grass (78).

Includes Agrostis geminata

Origin and Range

Native. Alaska to Newfoundland and south to all but the southeastern United States. Also in Asia (507). It is a variable species (435). Var. geminata (Trin.) Swallen is also found in Alberta (312).

Growth Habit

Tufted bunchgrass, 30 to 70 cm high (312). It forms small, dense tufts (435).

Nitrogen Fixing - None

Longevity - Perennial (312).

Self Propagation

At maturity the inflorescence breaks away and is carried off by the wind like a tumbleweed. This facilitates dispersal to areas far removed from the place of origin (312, 78).

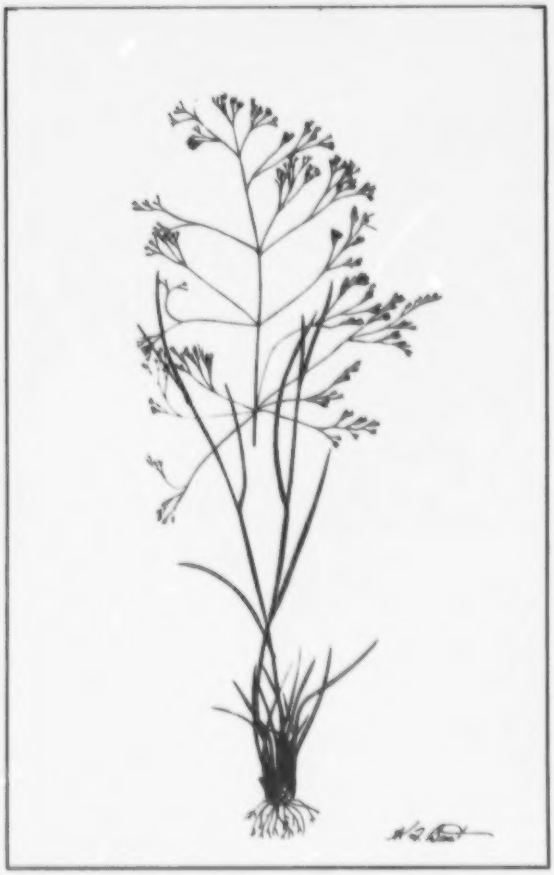
Ecological Setting

Hairgrass is found from near sea level to the subalpine (507). It is found on dry, open slopes and alluvial flats (214). It is also found on moist ground in meadows, open woods and abandoned fields even in dry areas (312, 78). Var. geminata is found on alpine slopes in Alberta (312). Hair grass has been reported to be found in moist sites from 2 000 to 3 330 m in Wyoming (18). Seed has been collected at 2 000 m in Alberta (380).

TOLERANCES

Soil Preferences

Hair grass has been successfully established on barren, gravelly, stony and rocky slopes when adequate fertilizer was applied (478).



Nutrient Requirements

Hair grass is adapted to soils of low nutrient status (476).

Soil Reaction

Hair grass can tolerate soils of low pH (476). It is an early colonizer of barren acid (pH 4.0) soils near Coniston, Ontario (478).

Soil Salinity

Tolerant of mildly saline soils.

Drought

Drought tolerance is probably moderate since it colonizes bare, sandy soil near Coniston, Ontario (477). It is also found on dry, open slopes in the mountains (214).

Heavy Metals and Hydrocarbons

Hair grass has been found growing on soils with total Cu and Ni contents of up to 450 ppm and 500 ppm respectively (478).

Shade

Generally found in open sunny locations, so it is presumed to be relatively shade intolerant.

Grazing or Mowing

No specific tolerances noted in the literature reviewed, although the habits of this species would suggest that it is reasonably tolerant of grazing. Many Agrostis spp. are used for putting greens of golf courses; tolerant of very close mowing.

Susceptibility to Disease and Insect Damage

Some ecotypes are resistant to snow mold (Sclerotinia borealis) (435).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Hair grass produces very lush growth the first year, if fertilized. The resulting dense cover provides an effective ground cover to prevent surface erosion (478).

Adaptation to Disturbance

Hair grass is a common pioneer of abandoned fields throughout the prairies (145, 78). It is a pioneer of barren, sandy soil near Coniston, Ontario (478). It is not necessary to seed hair grass in an area where there is a seed source nearby since it is very efficient at seed dispersal by tumbling mechanisms (478). Hair grass has been reported as a pioneer on a relatively dry white spruce area, near Norman Wells, N.W.T. (45). It has been noted as a pioneer of disturbed areas in Alberta (455).

Competitive Ability

Moderately aggressive in adapted areas.

Commercial Value

Some Agrostis spp. are used for lawns and golf courses, particularly putting greens where their growth form allows development of a very fine, short turf.

Palatability and Nutritive Value

No indication of palatability or nutrient value for this species was found in the literature reviewed.

Seed or Planting Stock Availability

No commercial supply of A. scabra seed is available. Seed for several related species (A. tenuis, A. alba, and A. palustris) is available from commercial suppliers although it is generally very expensive.

Methods and Ease of Establishment

Primarily by seed although sprigging has been successful for related species.

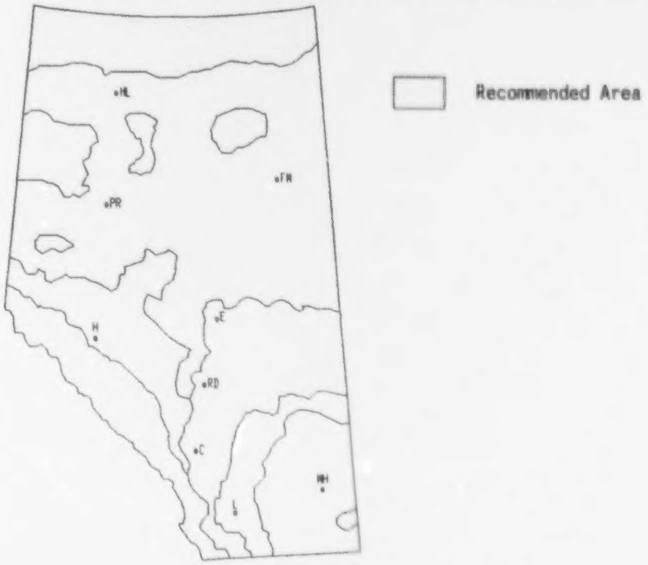
Current Status for Reclamation

Seed of hair grass has been collected in Alberta for genetic improvement (455, 453). When established on fertilized ground, hair grass produced very lush growth the first year, but it tended to act more as an annual than a perennial. The thick thatch form retarded regrowth in the second year and establishment of other species (378). In a field trial near Tent Mountain in Alberta, hair grass produced greater than 20% cover on fertilized plots after the first growing season (10).

Hair grass is a variable species found in dry and moist sites from the prairies to the mountains. Var. geminata is found on alpine slopes. The species is tolerant of very acid soils and soils low in nutrients. Some ecotypes are resistant to snow mold. It has good potential for use in reclamation in Alberta. Further research is needed into suitable ecotypes and methods of establishment.

Alopecurus arundinaceus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance				X	X	
Salt Tolerance					X	
pH Tolerance	Acid		X			
	Base				X	
Winter Hardiness		X	X			
Erosion Control			X			
Persistence		X				
Palatability			X	X		
Browse Tolerance			X			
Moisture Preference		Moist to wet, endures considerable flooding.				
Soil Preference		Medium to heavy textured, poorly drained.				

Alopecurus arundinaceus Poir.

SPECIES BIOLOGY

Taxonomy

Creeping Foxtail (183, 139, 179), Creeping Meadow Foxtail (426, 5)

Origin and Range

Creeping foxtail is native to Eurasia (183, 199). The species is variously considered native (132, 500) and introduced (391, 183, 426) in North America. It was apparently brought to the U.S. by homesteaders from eastern Germany or the western USSR, probably around the turn of this century (183). It has since escaped and is now present in many areas of western and northern North America (183, 426).

Growth Habit

A tall, erect sod-forming grass, with strong rhizomes (183, 426). It may reach heights of 80 cm (139) or more under favorable conditions (500). *A. pratensis* (meadow foxtail) is a related species of similar growth habit (183, 179, 500).

Nitrogen Fixing - None

Longevity

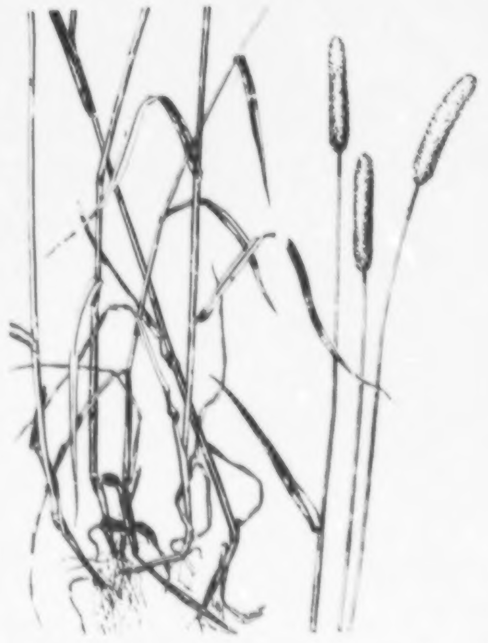
Long-lived, cool season (639) perennial (179, 183, 426), that shows excellent persistence at high altitudes and in the north (41, 5). Good winter hardiness (240, 5). Can survive at least 18 years at high elevations (3 770 m ASL) (213).

Self Propagation

Natural seed production is low (5). Seedling vigor is described variously as weak to moderate (41, 5, 179) to excellent (D. Walker, pers.comm.). It is the only commercially available species able to set viable seed in the upper subalpine (41). Principle means of self propagation is by vegetative spreading from the strong rhizomatous root system (183, 391).

Ecological Setting

Performs best in moist situations such as wetland pastures and mountain meadows (183). Requires a minimum of 63 cm of precipitation (639). Its high tolerance of flooding (5) and cold temperatures ensures its success for very moist situations throughout the area. Suited to both high elevations (41) and high latitudes (5). Successful at the Climax molybdenum mine (Colorado) at about 3 400 m ASL (236) and 2 200 m ASL at Marmot Basin (65° latitude) in Alberta (D. Walker, pers.comm.).



TOLERANCES

Soil Preferences

Prefers medium and heavy textured soils (5, 500) that are poorly drained (179). Creeping foxtail endures considerable flooding (5) and is best adapted to fairly moist conditions (183). Favored soils include saturated or "groundwater" Podzols and humid forest soils such as the poorly aerated, saturated "claypan" soils (179). Gleysols or gleyed Luvisols should also be suitable.

Nutrient Requirements

Noted to have moderate to high nutrient requirements (5, 426). Meadow foxtail (*A. pratensis*) also requires good fertility (391, 5). Good crop management often includes a mid-season nitrogen fertilizer application (179). Establishment and early growth is aided by low nitrogen fertilizer applications (179). Phosphorous applications yield particularly good responses (380).

Soil Reaction

Adapted to strongly acid to neutral soils (5, 179, 500).

Soil Salinity

Little indication, though it has been suggested that creeping foxtail may endure slight salinity (500).

Drought

Moderately tolerant of short droughty periods (500), though overall resistance must be considered poor (5).

Heavy Metals and Hydrocarbons

Creeping foxtail has performed well on coal overburden spoils (with unknown hydrocarbon content) (380). No other notes of growth on potentially phytotoxic materials have been gathered from the literature.

Shade

Presumably it tolerates some shade, as does meadow foxtail, and grows well in deciduous forest stands (339).

Grazing or Mowing

Creeping foxtail has a moderate recovery rate after cutting (5). A. pratensis is noted to have excellent tolerance to grazing (339).

Susceptibility to Disease and Insect Damage

No particular sensitivities or tolerances to diseases or insect pests have been noted from the literature consulted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Creeping foxtail is a useful and effective erosion control species (186, 426). It has been improved, in part, for use in waterway stabilization (266) and is used for highway turf purposes (298), for ski slopes (236) and for minesite slope stabilization (380), especially at high elevations and in moist situations. Its vigorous sod-forming habit and wide adaptability may be credited.

Adaptation to Disturbance

Probably can be considered moderate, at least where it is able to vegetatively invade.

Competitive Ability

Creeping foxtail is at least a moderately good competitor, reducing the invasion of weedy grass (179). Considered to have medium to strong aggressiveness on moist to wet sites (500, 644). Though some report that it has poor compatibility with other species (5), others disagree regarding meadow foxtail (500). It is frequently seeded with alsike or white clover (Trifolium hybridum or T. repens), big trefoil (Lotus uliginosus) or timothy (179).

Commercial Value

The species is used for pasture, silage and hay purposes (179) and for erosion control (183), including waterways (266), highways (298) and ski slopes (236).

Palatability and Nutritive Value

Both creeping (Alopecurus arundinaceus) and meadow foxtail (A. pratensis) are moderately to highly palatable. Both green up early and remain palatable throughout the growing season (41, 183, 391, 426, 427, 339, 179, 5). In one test, it ranked second only to timothy (Phleum pratense) among 20 grasses tested (179). Deer and elk favor meadow foxtail for its early growth and new shoots throughout the summer. Livestock favor the forage (339). Forage yield is high.

Seed or Planting Stock Availability

"Garrison" is the only cultivar of creeping foxtail commercially available in Canada and the U.S. Though readily available (183,426), it may be quite expensive (41). It has good yields of high quality forage, and is well adapted to wetland sites (183) or irrigated pastures (426). Approximately 900 000 seeds/lb (639). Four cultivars of meadow foxtail (A. pratensis) are available. These include "Dan", "Oregon", "Polano" and "Rhona" (139).

Methods and Ease of Establishment

Seed is fluffy and it will not distribute at all in common drills (41). Combining with an inert material such as rice hulls, vermiculite or cracked corn will ensure that seed is properly delivered (391, 179, 41). Coated seed is suggested for easier handling (D. Walker, pers. comm.). Seeding in combination with one or more legumes is also advised (179). Fertilization with a low nitrogen product at the time of seeding will aid establishment (179), which is a sensitive period for the species. Unprocessed seed retains 70% viability over 10 years storage in cool, dry conditions (179). Irrigation would probably be useful if the adequacy of moisture is in question. A fall or spring seeding at a rate of 3 to 4 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

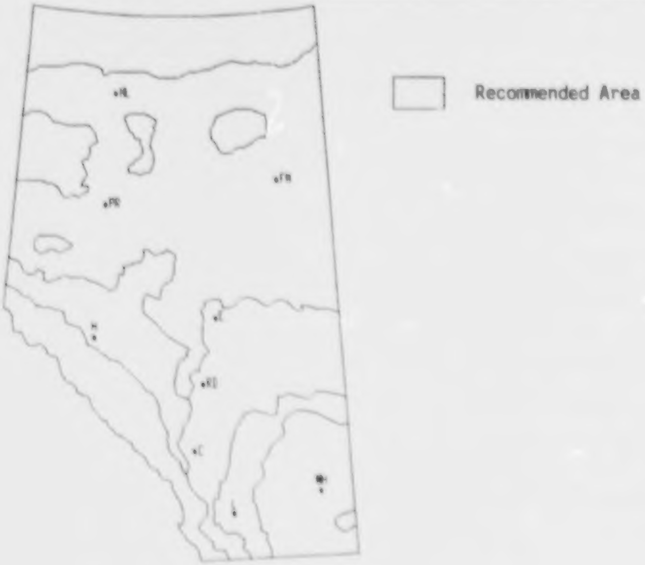
The species is widely used as a hay, silage and pasture species in the northern great plains, Pacific northwest, the U.S. intermountain region, and in Alaska (5, 183). Experimental work at high elevations in Alberta and British Columbia has been encouraging (380, 498). It was consistently successful in subalpine and alpine test sites along the eastern slopes region (705), but required fertilization to maintain growth after two years (740). It became the dominant species in mixed seedings on moist to wet sites on a pipeline right-of-way in the Upper Mackenzie Region of the boreal forest (644), but only provided short-term (one to two year) cover in the arctic tundra (644). Noted to be less aggressive than reed canary grass for stabilizing irrigation canals (635).

Creeping foxtail is also commonly used for high elevation reclamation or rehabilitation of disturbances in the western U.S. (236, 213).

Major assets include its winter hardiness, tolerance of excessive soil moisture and flooding, acid tolerance and strong rhizomatous habit. It is not a strong reseeder, however, and is very sensitive during its weak seedling stage.

Arctagrostis arundinacea

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid	2-3				
pH Tolerance Base					
Winter Hardiness	X				
Erosion Control		X			
Persistence			X		
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Moist, withstands flooding.				
Soil Preference	Moderately well to imperfectly drained, cold soils.				

Arctagrostis arundinacea (Trin.) Beal

SPECIES BIOLOGY

Taxonomy

Reed Polar Grass (405), Polar Grass (34).

Varieties include A. latifolia var. latifolia, A. latifolia var. arundinacea (Trin.) Griseb. (405, 312).

Origin and Range

Native. In Alberta, its main distribution is in the northern part of the province, particularly the Caribou Mountains (312). Arctagrostis latifolia var. latifolia is the more northern circumpolar form (490). Arctagrostis latifolia has a circumpolar distribution and a north-south range between 55° and 85° latitude (490). Arctagrostis is a truly northern genus, having no species occurring below 50° N (111).

Growth Habit

Relatively tall grass reaching 40 to 100 cm tall (312); var. arundinacea is taller than var. latifolia, being up to 150 cm tall. Slowly expanding growth by rhizomes produces a dense bunch-like appearance (111).

Nitrogen Fixing - None

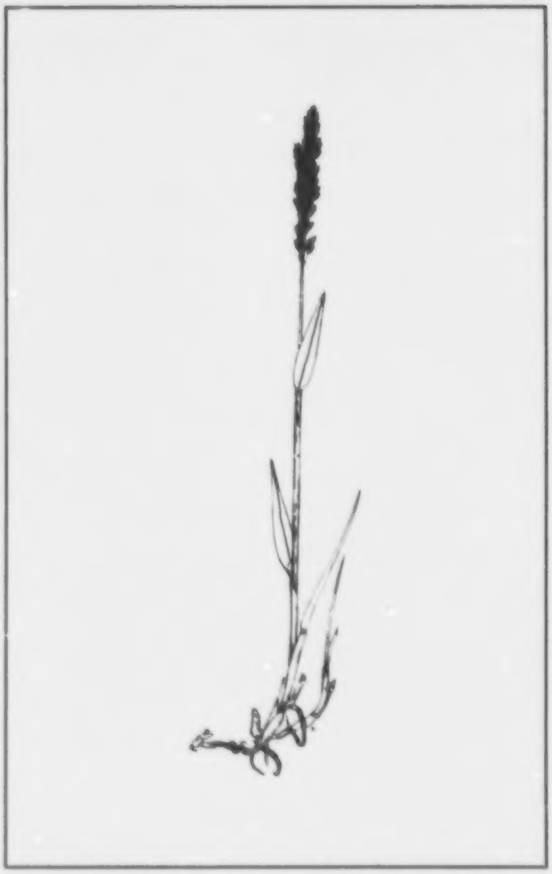
Longevity - Perennial grass (405).

Self Propagation

Propagation is by seeds as well as by stout rhizomes (490). Relatively few flowering heads are produced in undisturbed plant communities (490). Seeds of Arctagrostis are very light and are easily windborne. Seed maturity occurs late in the growing season with seeds remaining viable over the winter for early spring germination (490).

Ecological Setting

Wetland plant (405). Var. latifolia is found in wet meadows, along rivers, and on the tundra (214); var. arundinacea is found in meadows and sandbars along rivers (214). Var. latifolia tolerates a wide range of tundra conditions and is found as a common, but minor, member of most tundra plant communities, generally occupying better drained positions (490). Component of early seral stages, at least up to six years following fire in tundra vegetation. Associated with shrubs such as Betula glandulosa, herbs such as Epilobium angustifolium, and other grasses such as Calamagrostis canadensis (460). In the Mackenzie Delta region, reed polar grass is found on deposited sediments along river channels and lake shores subject to flooding, and associated with willows (Salix spp.) and herbs such as horsetail (Equisetum arvense) (97).



TOLERANCES

Soil Preferences

In the arctic tundra, var. latifolia is common on imperfectly to moderately well drained habitats in all topographic positions; most important on imperfectly drained areas, decreasing in importance on dry upland or wet lowland sites. Requires a minimum depth of 35 cm of active soil and favors areas where mineral soil is covered by only a thin layer of organic matter (490, 111). On river alluvium in northern Alaska, it is restricted to areas of deepest sand and silt (52).

Nutrient Requirements

Fertilizer application noted to stimulate growth of reed polar grass (110).

Soil Reaction

Local populations of reed polar grass were found growing in very acid environments in the Northwest Territories (soils with pH 2.0 to 3.0 compared to normal tundra soils pH 7.0 to 7.5). Greenhouse and field trials indicated that plants from this stock outperformed other species tested (Deschampsia caespitosa and Hordeum jubatum) on various acid tailings conditions (246); amelioration of tailings increased growth responses.

Soil Salinity

No specific tolerances noted, but generally not found on saline sites.

Drought

Low evapotranspiration in areas of favored growth indicates low drought tolerance.

Heavy Metals and Hydrocarbons

Greenhouse and field trials of reed polar grass on various acid tailings materials indicated tolerance to high levels of Ni, Cu and Zn. Grew better than Deschampsia caespitosa and Hordeum jubatum on a wide range of acid tailings conditions, associated with increased solubility of heavy metals (246).

Shade

Generally not found in excessively shady sites.

Grazing or Mowing

Can withstand a moderate degree of grazing.

Susceptibility to Disease and Insect Damage

No specific susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Arctagrostis is characterized by penetration of root systems into progressively colder soils, an adaptation to permafrost environments; it produces a root system which is 2 to 3 times larger than that of Calamagrostis canadensis (484). These attributes may be useful for soil stabilization and erosion control. Both species had better root growth than the agronomic species tested (223).

Adaptation to Disturbance

Rapid growth, rhizomatous spreading ability, and vigorous seed production result in rapid colonization of disturbed moist to dry sites (490), and streamsides as in the Prudhoe Bay area (459). Noted for invasion of mineral backfill in pipeline operations along the Mackenzie River (110). Var. latifolia is an important colonizer of disturbed upland tundra habitats except for those which are very wet (490). Flowering and seed production of plants growing on disturbed sites was greater than on undisturbed sites (86% vs. 29%) (490). A. latifolia and other grasses such as Calamagrostis canadensis were observed invading seismic lines in the Mackenzie Delta region, with plant cover and frequency greater than in natural tundra (194). Along with fireweed (Epilobium angustifolium) and Calamagrostis canadensis, A. latifolia is the most dramatic increaser in burned areas in the forest tundra (460).

Competitive Ability

A. latifolia has cold tolerant roots and is not particularly well adapted to competition for nutrients in the upper, warmer soil horizons where most roots are concentrated (490). The species is slow to establish in an area and seems susceptible to competition during the seedling stage; however, once established, it grows quickly and can flower by the second year (195).

Commercial Value

Value appears to be primarily for stabilization of soil disturbances and for wildlife forage.

Palatability and Nutritive Value

Reed polar grass had nitrogen and phosphorus contents of 1.4% and 0.15%, respectively, in July before flowering and 0.8% and 0.1%, respectively, in August after flowering. Var. arundinacea grown in fertilized gardens in Alaska had a mean nitrogen content of 2.8% (490). Used for food by voles (110).

Seed or Planting Stock Availability

Not known to be available commercially in Canada. Licensed in the United States by W.W. Mitchell (in Alaska); the cultivar is called "Alyeska" (D. Walker, pers.comm.).

Methods and Ease of Establishment

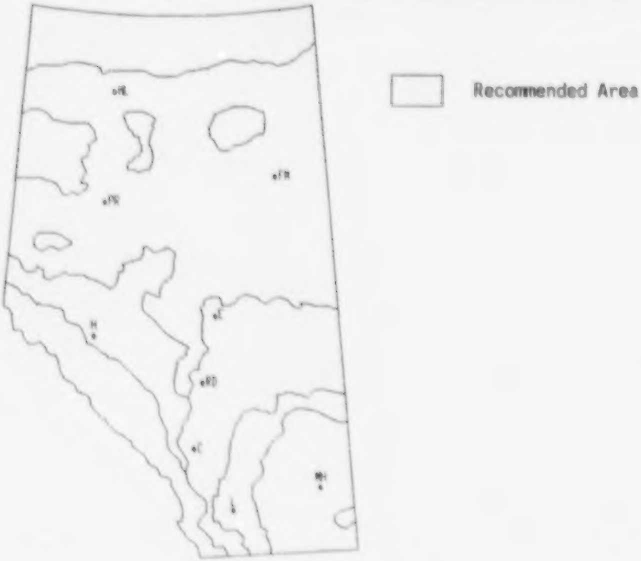
Seed of *A. latifolia* is exceedingly small and difficult to harvest and apply (P. Ziemkiewicz, pers.comm.). Seed is to be applied in two sowings, one-third at the initial seeding, the remaining two-thirds 2 years later, with a booster fertilizer dressing (398). Initial establishment of *A. latifolia*, after two years on reclamation trials in the Northwest Territories, was inferior to the agronomic species used; after seven years it was many times more successful (34). Unlike many tundra species, the seed of *A. latifolia* var. *latifolia* germinates over a wide range of temperatures and requires no special pretreatment (490). Germination%age in the field ranged from 65 to 75% (307), and 80 to 90% in non-stratified and cold stratified laboratory tests although in a polar semi-desert situation, it ranged from 0 to 16% (35). *Arctagrostis* had higher and more consistent germination%ages at all temperatures than most other tundra grasses (307) tested. Seed germinates in six days (35).

Current Status for Reclamation

A. latifolia is best adapted for revegetation of disturbed tundra or boreal forest sites, particularly where permafrost is present. In Alberta, range extends north of 55° N latitude, although revegetation research is limited to arctic tundra and Mackenzie Delta locations. Attractive features of this species include aggressiveness once established, low winter kill, and tolerance to cold soils. Further research is warranted on tolerance of polar grass to acid soils and tailings in northern environments. Reed polar grass has been tried on tundra desert (King Christian Island) (3) and elsewhere in the Yukon and Northwest Territories (490, 398, 307, 160, 35). *Arctagrostis arundinacea* has been recommended for revegetation in foothills and mountain areas (435).

Bromus inermis

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance			X		
pH Tolerance Acid			X		
pH Tolerance Base			X		
Winter Hardiness		X	X		
Erosion Control		X	X		
Persistence	X	X			
Palatability	X	X			
Browse Tolerance		X			
Moisture Preference	Moist to dry.				
Soil Preference	Loamy to clay, fair on sand.				

Bromus inermis Leyss.

SPECIES BIOLOGY

Taxonomy - Smooth Brome, Awnless Brome

Origin and Range

Introduced from Europe and Asia (339). Circumboreal distribution. Cultivated in Alaska, and from British Columbia to Newfoundland and south to the Great Lake states and California (214). Smooth brome is the most widely adapted species on western ranges (339). Hybridizes with *B. pumpellianus* (214). There are two types of smooth brome recognized. The southern type was introduced from France and Hungary into the United States about 1880, and from there into Canada. The northern type was introduced to Canada from Germany about 1880 (138). A number of varieties of each, as well as intermediate northern-southern types, are licensed in Canada (138).

Growth Habit

Smooth brome is a tall, leafy, sod-former (138). Northern types are generally weakly rhizomatous and form an open sod (for example, variety "Carlton"), although some grow as bunchgrass; southern types are aggressive sod-formers (rhizomatous) and develop a tight sod (for example, variety "Lincoln") (138, 338).

Nitrogen Fixing - None

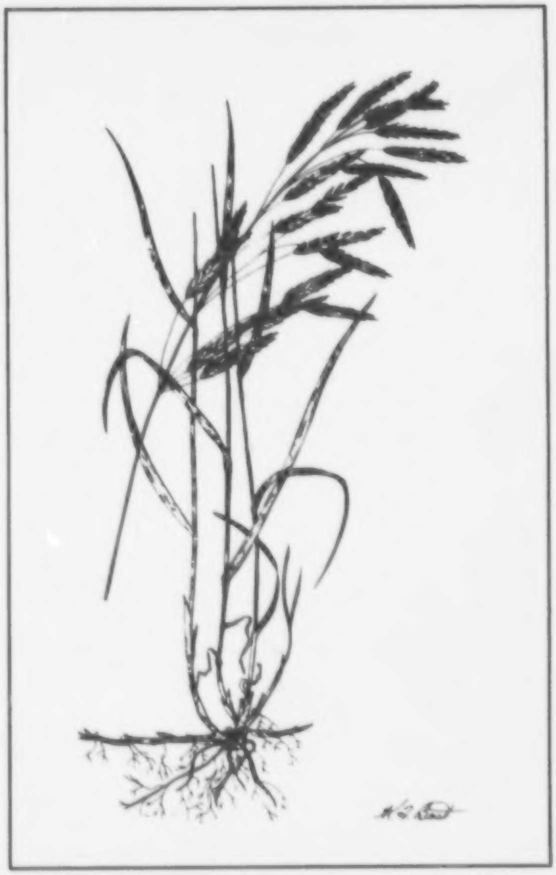
Longevity

Smooth brome is a rapid growing, long-lived, cool season (712) perennial (179). Many plantings in the United States are more than 60 years old (339). "Polar" smooth brome is a variety (a cross between *B. inermis* and *B. pumpellianus*) developed in Alaska which is particularly winter hardy (4).

Self Propagation

Primarily by seed. It spreads vegetatively by rhizomes (2, 138). Spread by reseeding has been rated moderate, and natural vegetative spread has been rated good (338).

Ecological Setting



Introduced as a forage crop, smooth brome persists as a weed. It is common along roads and in waste areas throughout the Canadian prairies (312, 78). The northern type is apparently more productive than the southern type in aspen parkland, subalpine and alpine ranges. The southern type is better suited to winter game range areas in Utah (339). The minimum annual precipitation at which smooth brome becomes established and produces well has been reported variously as 28 cm (339), 38 cm (179), and 30 to 45 cm (639). The northern type is better suited to western Canada, while the southern type is best suited to southern British Columbia and eastern Canada (138). The southern type has earlier spring growth while the northern type has even growth throughout the season (179).

TOLERANCES

Soil Preferences

Smooth brome is highly adaptable to a wide range of soil conditions (256), although apparently best suited for Chernozemic, Luvisolic, and Podzolic soils (179). It has only a fair tolerance of wetness and flooding (5). Smooth brome can grow on organic soils (436). It is adapted to a moderate range of soil textures (5). Growth on sandy soil is reported to be fair, while on loamy and clayey soil growth is good (446). In Alberta, it is more prevalent on fine textured soils than on coarse textured ones (435).

Nutrient Requirements

Smooth brome is variously reported to have high fertilizer requirements (5) and low nutrient demands (433). It has a high nitrogen requirement (41).

Soil Reaction

Smooth brome cannot tolerate soils that are more than mildly alkaline (179). Although reported to have poor tolerance of acid soils (5), smooth brome comprises the dominant cover on coal spoil with pH 4.5 at a site in southeastern B.C. (P. Ziemkiewicz, pers.comm.). A lower limit of pH 5.0 has been defined for the eastern US (712).

Soil Salinity

Smooth brome is fairly saline tolerant (426). Brome is moderately tolerant of salts within the range 5 to 10 mS/cm (468). Smooth brome did not do well when seeded on sodic soils in Alberta (435).

Drought

Smooth brome is a drought resistant grass (256, 5).

Heavy Metals and Hydrocarbons

Smooth brome is reported to have good tolerance of oil (113, 5).

Shade

Smooth brome can tolerate shade and for this reason it is desirable on brushy range areas where it can open up brush thickets (339).

Grazing or Mowing

Smooth brome can maintain itself better than most other grasses under very heavy grazing (339). Recovery of smooth brome after cutting has been rated as moderate (5).

Susceptibility to Disease and Insect Damage

Some varieties are fairly susceptible to leaf spot (Selenophoma bromigena) and Pyrenophora bromi (138). Smooth brome is also susceptible to damage by pocket gophers, presumably because of the fleshy rhizomes (41).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The northern type tends to have open sod, whereas the southern type is more aggressive and develops a tight sod (339). Smooth brome increased the organic matter content and moisture retaining properties of mine spoils (227). Smooth brome has very good soil stabilizing ability and good growth rate (338, 339). Smooth brome was found to improve ground cover and reduce erosion when planted on disturbed areas in the ponderosa pine-bunchgrass habitat (302).

Adaptation to Disturbance

Adaptation of smooth brome to disturbance has been rated as good (338).

Competitive Ability

Compatibility of smooth brome is high (5, 179), but will dominate other grasses if it is fertilized heavily (41).

Commercial Value

Smooth brome is used with alfalfa for hay and pasture.

Palatability and Nutritive Value

Smooth brome is palatable to all livestock, and yields of forage and seed are good (179). It is also palatable to game. The northern type is generally preferred because it is more leafy (339).

Seed or Planting Stock Availability

Varieties licensed for use in Canada include "Baylor", "Beacon", "Blair", "Carlton", "Fischer", "Lincoln", "Magna", "Manchar", "Redpatch", "Saratoga" and "Tempo" (138). Widely available from commercial suppliers. Approximately 125 000 seeds/lb (639).

Methods and Ease of Establishment

Smooth brome has fair (712) to good establishment by seed and excellent establishment by transplanting (338). Seedling vigor is good (5). Typical seed viability and germination is about 92 and 85%, respectively (376). Smooth brome also has rapid emergence and early spring growth (436). Seed is relatively inexpensive and is easy to handle

(41). A seeding rate of 15 to 20 lbs PLS/ac has been recommended for the eastern US (712), and 8 lbs PLS/ac in a fall/spring seeding for the western US (639). Establishment requirements of smooth brome are low (446). Seedlings and pieces of sod can be transplanted successfully on eroded sites (339).

Current Status for Reclamation

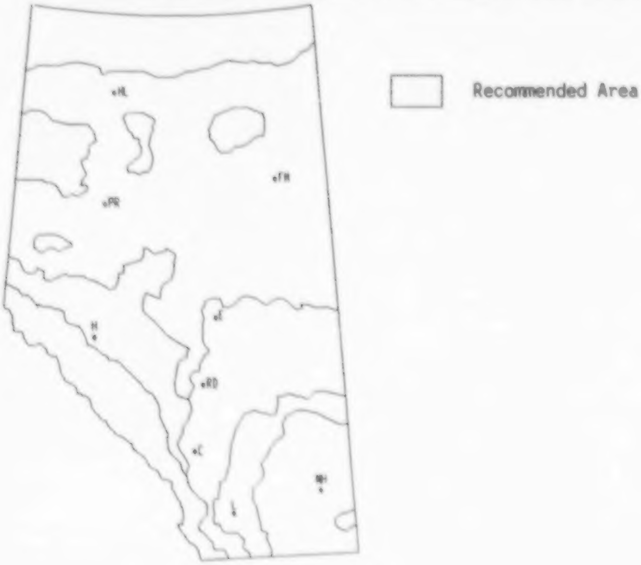
Smooth brome is one of the most valuable cover species throughout Alberta. It is present, if not the dominant cover type, in every region (435). Performance of "Polar" smooth brome was rated as good after two growing seasons at an alpine site in Alberta. "Baylor" smooth brome did not overwinter well at the same site (377). "Manchar" smooth brome produced acceptable cover at three years on a subalpine site at Tent Mountain and was recommended for use in the eastern slopes region (723). "Carlton" and "Manchar" smooth brome exhibited excellent vigor and survival after three seasons in the Upper Mackenzie region of the boreal forest at latitude 63° N (644). At Fort McMurray "Carlton" smooth brome has persisted in mixed stands for 17 years on amended tailings sand on moist sites. Smooth brome had moderate performance above and below the tree line in the northeast coal block of B.C. as well. In the southern interior smooth brome performed well on waste rock, overburden and tailings at 6 mine sites (143).

"Manchar" smooth brome has been recommended for revegetation of critical sites in northwestern Colorado. It is best suited to moist regions and elevations greater than 2 670 m (427). "Manchar" smooth brome was included in a seed mix suitable for use in the subalpine in Colorado (73). Smooth brome seed on coal mine spoils in northwestern Colorado at 2 200 m ASL was a major component of the plant canopy 4 years after seeding (307). "Manchar" has been used for revegetation at Vail, Colorado both below and above 3 300 m ASL (462). It has proved to be persistent in the subalpine largely due to reproduction by rhizomes. "Polar" has been recommended for revegetation of surface disturbances in the permafrost area of Alaska (79).

This species has low establishment requirements, early spring growth and rapid seedling emergence. It also spreads vigorously by rhizomes. Although it does best on moist sites, it is somewhat drought resistant. It is also a long-lived perennial that is moderately tolerant of saline soils. Varieties that are disease resistant and winter hardy would be useful for reclamation throughout the province, especially for providing initial cover and controlling erosion.

Bromus marginatus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance				X		
Salt Tolerance					X	
pH Tolerance	Acid				X	
	Base			X		
Winter Hardiness			X			
Erosion Control			X			
Persistence				X		
Palatability			X	X	X	
Browse Tolerance			X			
Moisture Preference		Moist sites.				
Soil Preference		Loamy to clay texture.				

Bromus marginatus Nees.

SPECIES BIOLOGY

Taxonomy

Erect Brome (78), Mountain Brome (183)

Origin and Range

Native. Mountain brome is found in the northern and central Rocky Mountains, and the northern portion of the intermountain and Pacific coast regions of western North America (183, 214, 426). In Alberta it is found mainly in the southwest (312), and in the Cypress Hills (78). It is closely related to *B. breviaristatus* (Hook.) Buckl. and *B. carinatus* H. & A., and it may be treated as a variety of the latter species (312). Some authors consider *B. carinatus* to be a polymorphic species that includes *B. marginatus* (183). "Bromar" mountain brome is a variety developed in the United States (183).

Growth Habit

Mountain brome is a robust bunchgrass 60 to 120 cm high (312).

Nitrogen Fixing

No rhizosheath noted on plants growing on disturbed sites (P. Lulman, pers.comm.). Does not fix atmospheric nitrogen.

Longevity

Short-lived, cool season (639) perennial (41, 183).

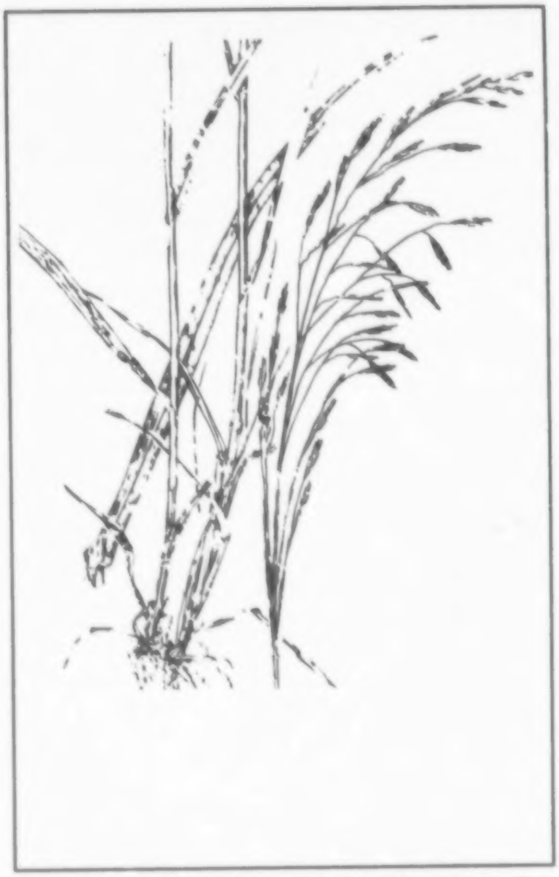
Self Propagation - Seed.

Ecological Setting

Mountain brome is found in woods and open slopes in southwestern Alberta (312). It has been reported in moist habitats between 2 230 and 3 000 m in Wyoming (18). Mountain brome is best adapted to areas receiving about 40 cm (639) to 45 cm (426) mean annual precipitation.

TOLERANCES

Soil Preferences



Mountain brome has been recommended for planting of critical sites on both loamy and clayey soils (424). It has been used for soil conservation in the Pacific northwest and great basin states on Chernozemic and Luvisolic soils (179). It is therefore adapted to a range of soil types and textures.

Nutrient Requirements

Good growth on low nutrient sites indicates low requirements.

Soil Reaction

Tolerant of mildly acidic to moderately alkaline soils. Prefers soils derived from basic parent materials.

Soil Salinity Tolerance

Bromar mountain brome has only fair salt tolerance (424).

Drought

Moderately drought tolerant, but prefers moist sites.

Heavy Metals and Hydrocarbons

No specific tolerances noted in the literature reviewed.

Shade

Will tolerate partial shade but prefers full sunlight.

Grazing or Mowing

Can be heavily grazed on alpine and subalpine ranges with little damage.

Susceptibility to Disease and Insect Damage

Mountain brome is susceptible to head smut, so seed must be treated with a fungicide before planting (179).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Mountain brome has a deep, well branched root system that is good for erosion control (183). It has a fair rate of spread (424).

Adaptation to Disturbance

Noted to invade disturbed sites in adapted areas.

Competitive Ability

Moderately aggressive but compatible with legumes.

Commercial Value

"Bromar" mountain brome is outstanding in performance in mixtures with sweet clover (Melilotus spp.) or red clover (Trifolium pratense) for pasture or green manure (183).

Palatability and Nutritive Value

Mountain brome is high in crude protein and digestible carbohydrates (179). Utilization of Bromus spp. has been rated as high for elk, moderate for mule deer, and low for bighorn sheep and moose (144). Mountain brome has been rated as a desirable species for sheep and deer, and a preferred species for cattle and elk (425).

Seed or Planting Stock Availability

Breeder seed is apparently available in the United States (183). "Bromar" is available in the US (639). No licensed cultivars are available in Canada. Approximately 90 000 seeds/lb (639).

Methods and Ease of Establishment

The seed of mountain brome shatters, so harvesting must be done carefully (179). Typical seed purity and germination is 90 and 85% respectively (371). Seed had a viability of 70% after 3 years of storage (179). Seed is large and seedling vigor is not rated as good. "Bromar" mountain brome has greater seedling vigor than common mountain brome (426, 183). In a greenhouse experiment, 12 out of 40 seeds planted became established on soils collected from high altitude sites (131). Ease of establishment of "Bromar" mountain brome has been rated as excellent. A late spring seeding at a rate of 6 to 8 lbs PLS/ac has been recommended (639).

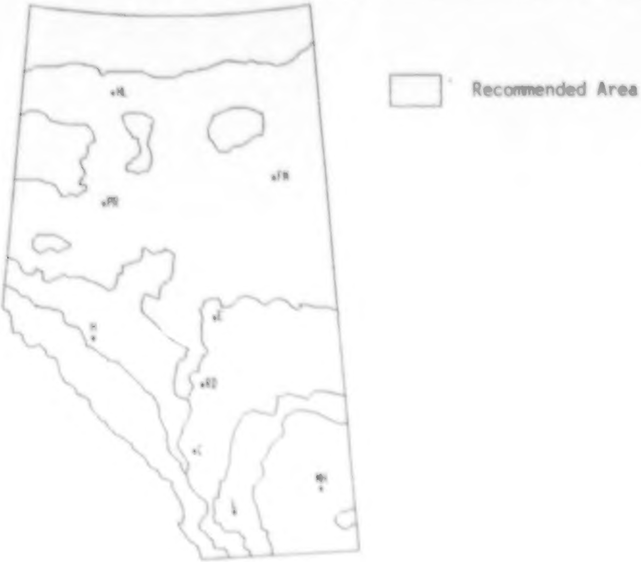
Current Status for Reclamation

Mountain brome has been recommended for use in the aspen zone in Colorado (106). It has been tested and recommended for revegetation of roadcuts and other disturbed sites in Utah (336). Mountain brome can be used to stabilize road cuts or mined lands where rapidly developed seedlings are required (426). "Bromar" mountain brome planted at several sites over 3 000 m in Colorado had only fair growth (236). This variety has been recommended for planting in critical areas in Colorado where mean annual precipitation is greater than 40 cm (424, 427).

Mountain brome is a rapidly developing, short-lived bunchgrass. It is only slightly tolerant of saline soils and prefers moist sites. Mountain brome has a high protein content and is highly palatable to livestock. The species has a deep, dense root system ideal for stabilizing erodible slopes. It has potential for use in reclamation and erosion control on moist sites to the subalpine in Alberta.

Calamagrostis canadensis

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance			X		
pH Tolerance Acid	3.5				
Base					
Winter Hardiness	X				
Erosion Control			X		
Persistence	X	X			
Palatability			X	X	
Browse Tolerance				X	
Moisture Preference	Moist to wet, good tolerance of flooding.				
Soil Preference	Wide range, moderately well to imperfectly drained.				

Calamagrostis canadensis (Michx.) Beauv.

SPECIES BIOLOGY

Taxonomy - Bluejoint, Marsh Reed Grass

Also *C. canadensis* (var. *macouniance* (Vasey) Stebbins) and ssp. *langsdorfii* (Link) Hult. (var. *scabra* (Kunth) (A.S. Hitchc.)

Origin and Range

Native. Bluejoint occurs throughout the boreal and temperate regions(297). Bluejoint is common in the subarctic and rare in the low arctic (223). Alaska to Quebec, south to all but the southeastern United States (507).

Growth Habit

Bluejoint is a tall grass, 60 to 120 cm tall. It has numerous leaves and creeping rhizomes, and forms tussocks (312, 214). It is particularly luxuriant in Alaska where it may reach heights of up to 200 cm within 6 weeks (297).

Nitrogen Fixing - None

Longevity

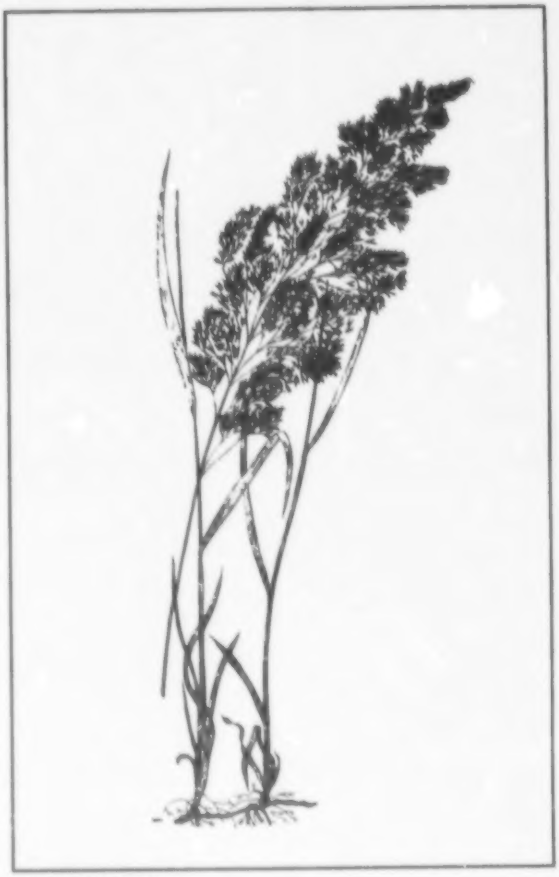
Long-lived perennial (312, 54). A well developed stand of bluejoint may persist for long periods, possibly as long as 100 years (4). It is very winter hardy (5, 240).

Self Propagation

Bluejoint spreads by seed and rhizomes. Seed yields are low (5) but seed has high viability (490).

Ecological Setting

Bluejoint occurs in a wide range of habitats from lowland wet sites to wind swept alpine ridges (490, 507). It is common in moist sites; marshes and moist woodlands throughout the North America prairies (451, 324, 78). It is often found in lowland hay meadows (347). It has been reported to occur on wet sites from 1 670 m to 4 170 m ASL in Wyoming (18). Bluejoint has been reported as a component of several community types in the Mackenzie Delta Region, N.W.T. (97). It is found in all habitats, except wet depressional, in the arctic tundra, being most prominent in moderately well drained uplands (490). It is the most abundant grass in Alaska and can withstand exposed sites (298).



TOLERANCES

Soil Preferences

Bluejoint prefers moist sites (180) but can survive on a wide range of moisture regimes from imperfectly to moderately well drained soils. It is found on both peaty and mineral soils, but more often on peat (490). Bluejoint is adapted to a wide range of soil textures. It has good tolerance to wetness and flooding (5).

Nutrient Requirements

Addition of fertilizer on tundra sites causes a marked stimulation, and an increase in the number of flowering spikes (216). Addition of fertilizer to revegetation plots in the Northwest Territories increased plant vigor and production (195). Bluejoint has moderate fertilizer requirements (5).

Soil Reaction

Bluejoint is tolerant of extremely acid soils, with pH values as low as 3.5 (298).

Soil Salinity

Moderately tolerant of saline soils.

Drought

Bluejoint cannot germinate under droughty conditions (461), although it has very good drought resistance once established (5).

Heavy Metals and Hydrocarbons

Bluejoint has been noted as a vigorous invader of oil spill sites in the Northwest Territories, and showed rapid recovery after spills (216).

Shade

Prefers open sites but will tolerate partial shade.

Grazing or Mowing

Yields of bluejoint were decreased by 15 to 20% when cut two to four times, by 35 to 45% when cut five to six times and about 70% when cut seven times, in relation to plots cut once at the end of the growing season (100). Forage yield potential has been rated as moderate. The recovery rate after cutting is slow (5). It is intolerant of heavy grazing (4).

Susceptibility to Disease and Insect Damage

Some bluejoint strains are susceptible to white top. This condition is caused by insect or fungal damage of the lower culms. Bluejoint is, in general, not susceptible to snow mold (298).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Bluejoint is a bunchgrass with a creeping growth habit (5, 312) and is capable of high ground cover production (436). The species is presumably a good erosion controller.

Adaptation to Disturbance

Bluejoint has been reported as a pioneer on dry disturbed sites near Norman Wells, N.W.T. (459). The ability of bluejoint to rapidly invade disturbed arctic tundra sites can be attributed to its small but highly viable and early germinating seed, and a root system that is tolerant of low soil temperatures (490). The seeds are easily wind-borne (242). Bluejoint tends to become established more slowly than commercial species, but by the third season, cover can equal or exceed those species (209, 195). Bluejoint has been reported as a pioneer on sand dunes in the Great Lakes region (482). It was found to be an important increaser on burned tundra sites (460). Bluejoint was found to be a better colonizer on disturbed sites in the northern boreal forest than on disturbed tundra sites (195).

Competitive Ability

Bluejoint was found throughout a wide range of tundra habitats, but in no habitat was it very vigorous or dominant. Bluejoint, however, is a dominant species on disturbed sites (490). This suggests that it has poor competitive ability. Other sources indicate good competitive ability (436) and fair compatibility (5).

Commercial Value

Bluejoint is an important hay meadow grass in Alberta (298). The species also has erosion control value.

Palatability and Nutritive Value

Bluejoint is not highly palatable to livestock at any time during the growing season, although it may be grazed in the spring. In general, good hay may be produced if it is cut in mid-summer. The chemical composition of forage is fairly good in comparison to upland grasses (180). Cattle forage value has been rated as fair (19). Palatability has been rated as moderate (5). In Alaska, bluejoint provides good, nutritious forage for cattle early in the season. Protein content is about 15 to 20% in mid-June, but decreases to 10 to 14% in early July and to 7 to 9% by early August (4).

Seed or Planting Stock Availability

The cultivar "Sourdough" bluejoint has been released for use in Alaska (298). No commercial sources or licensed varieties in Canada.

Methods and Ease of Establishment

Seed collected from near Inuvik, N.W.T., had a germination rate of 90% at 20°C (35). Cold stratification did not improve the rate of seed germination (490). Seedling vigor has been rated as moderate (5). Seed has been successfully harvested by a modified rasping bar thresher. It is a difficult species to harvest because the seed has many callus hairs which make the seed difficult to dislodge from the floret (242). The infloresçense also shatters (298); seed yields are usually low (490).

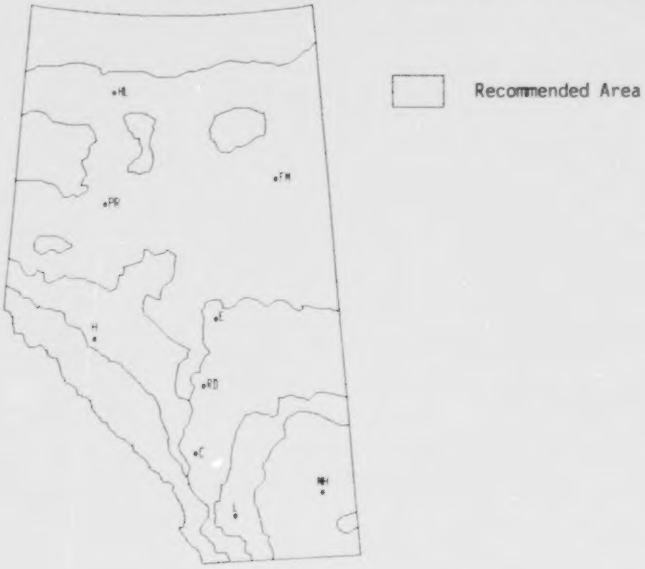
Current Status for Reclamation

Bluejoint has been evaluated for revegetation in several trials in tundra and northern boreal forest sites (209, 195). It was found to establish slowly, but by the end of the growing season, cover and biomass production equaled or exceeded those of commercial varieties. Annual production at this time was 2 to 8 times that of "Arctared" red fescue (Festuca rubra) and "Nugget" Kentucky bluegrass (Poa pratensis), the two most successful agronomic species used (209). Seed of bluejoint has been collected for revegetation trials in Alberta (209).

Bluejoint is a widely distributed grass that is adapted to a variety of habitats. It is generally found on moist to wet sites and can grow well on organic soils. It is very tolerant of acidic soils and is extremely winter hardy. It is an aggressive pioneer of disturbance sites and spreads by rhizomes. Bluejoint also has good drought tolerance once established. Because it has a high viability, there is potential for selecting populations for revegetation of specific sites in Alberta. Further research is needed into collection of seed, since seed yields are usually low and harvesting of seed is difficult.

Calamagrostis purpurascens

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance				X		
Salt Tolerance					X	
pH Tolerance	Acid					
	Base			X		
Winter Hardiness			X			
Erosion Control			X	X		
Persistence				X		
Palatability					X	
Browse Tolerance			X			
Moisture Preference		Dry.				
Soil Preference		Rocky, sandy to silty loam.				

Calamagrostis purpurascens R.Br.

SPECIES BIOLOGY

Taxonomy - Purple Reed Grass

Origin and Range

Native. Alaska south to California in the Olympic and Cascade Mountains. East to Quebec and south to Colorado through the Rocky Mountains, also in South Dakota and Minnesota. Also found in Greenland and throughout Asia (507).

Growth Habit

A tufted grass 30 to 70 cm tall. Purple reed grass sometimes has short rhizomes (312). It is characterized by purplish or pinkish compact heads (78).

Nitrogen Fixing - None

Longevity - Perennial (312).

Self Propagation

Purple reed grass spreads by seed and a very few genotypes creep (312).

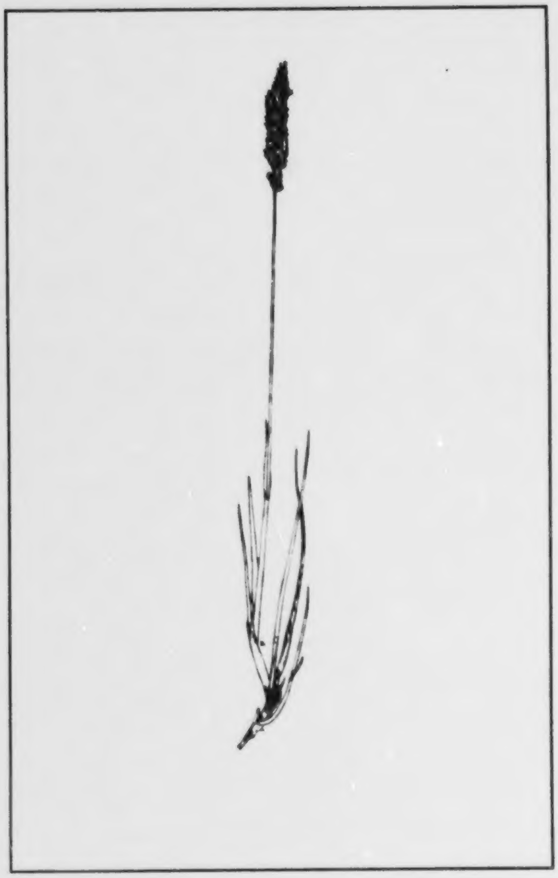
Ecological Setting

Purple reed grass is found in western and southwestern portions of the Canadian prairies (78). It is mainly found in the Rocky Mountains and the Cypress Hills in Alberta (312). Plants have been collected at Snow Creek Pass in Banff National Park at 2 170 m ASL (455). Purple reed grass has been reported as the dominant grass on a loose, sandy erosion slope in west Greenland (177). Calamagrostis purpurascens ssp. purpurascens was reported as a component of the Artemisia frigida community found on steep banks of the Mackenzie River, N.W.T. (97).

TOLERANCES

Soil Preferences

Purple reed grass is typically found on dry, rocky soil in open areas (507). Soil texture preferences range from sandy to silty loam.



Nutrient Requirements

Expected to have low nutrient requirements judging by its natural occurrences.

Soil Reaction

No references to pH range round in literature reviewed. Generally occurs on basic soils.

Soil Salinity

Will tolerate mildly saline sites.

Drought

Will tolerate moderately droughty conditions.

Heavy Metals and Hydrocarbons

Purple reed grass recovered well after oil spills and it appeared as a potentially useful species for recolonization of oil spill sites (216).

Shade

Prefers full sunlight, but will survive at reduced vigour under partial shade.

Grazing or Mowing

The low palatability of most Calamagrostis spp. generally enables it to maintain its vigor on all but the most seriously overgrazed ranges.

Susceptibility to Disease and Insect Damage

No susceptibilities noted in the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Fibrous roots as well as the ability to colonize hostile sites make this species a good soil builder and an effective erosion controller.

Adaptation to Disturbance

Small pieces of turf eroded from a roadcut in alpine and high subalpine areas in Washington resulted in the establishment of purple reed grass on the cutbank (36).

Competitive Ability - Not highly aggressive.

Commercial Value

Utilized by wildlife to a limited extent.

Palatability and Nutritive Value

Calamagrostis spp. have a relatively low palatability although purple reed grass is occasionally grazed by bighorn sheep.

Seed or Planting Stock Availability

Currently being developed, although seed not now commercially available.

Methods and Ease of Establishment

Generally by seed, although specific treatments have yet to be worked out.

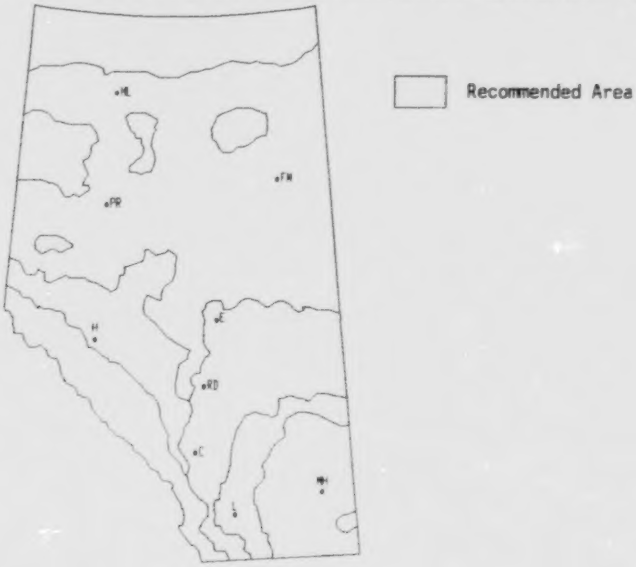
Current Status for Reclamation

Purple reed grass produced greater cover when planted on overburden topdressed with mineral soil compared to raw overburden at Cadomin (1 675 m ASL), Alberta. The seeds of purple reed grass have been collected for selection of strains suitable for revegetation in Alberta (455).

Purple reed grass is found from the foothills to subalpine rocky slopes in Alberta. It is moderately drought tolerant and is a pioneer species on disturbed mountain sites. It has some potential for use in reclamation in the Rocky Mountains in Alberta, but further research is required into genetic variability, seed handling and early management.

Calamovilfa longifolia

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance					X
pH Tolerance Acid				X	
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence			X		
Palatability			X	X	
Browse Tolerance				X	
Moisture Preference	Dry.				
Soil Preference	Sandy.				

Calamovilfa longifolia (Hook.) Scribn.

SPECIES BIOLOGY

Taxonomy

Sand Grass, Sand Reed Grass (47), Prairie Sandreed (639).

Origin and Range

Native (405). Sand grass is the only Canadian representative of the genus Calamovilfa. Its range spreads from the Rocky Mountains east to the Lake Superior region and southward to New Mexico and Kansas (9).

Growth Habit

Tall, erect sod-forming grass with coarse leafy stems up to 2 m tall (336) and long stout scaly rhizomes. Roots to a depth of up to 1.5 m although most are found within 7 cm of the surface (9). On mixed prairie, it is observed to grow in nearly pure stands or colonies ranging from about 1 m to 8 m in diameter (1). Also mildly to strongly rhizomatous (183, 199), with large, spreading rhizomes (1).

Nitrogen Fixing - None

Longevity

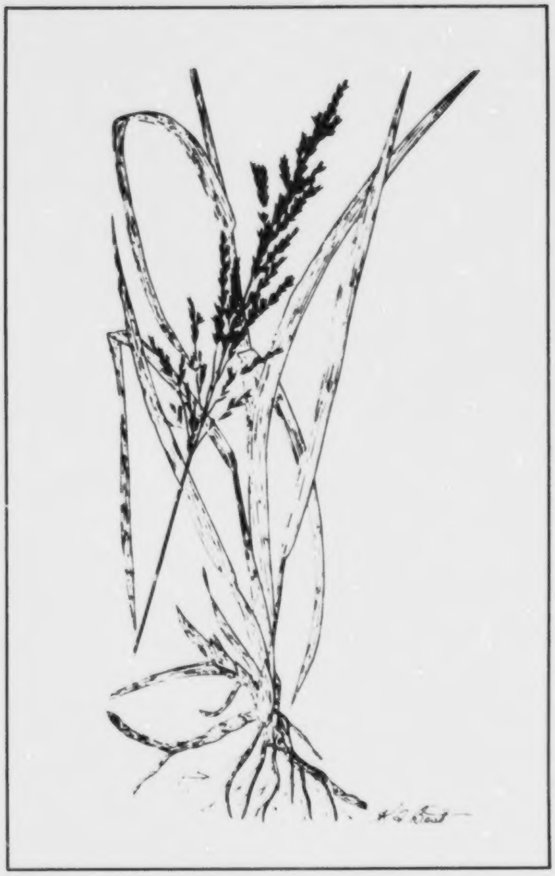
Warm season (639) perennial grass (312).

Self Propagation

Seed production is rated as good; although propagation is predominantly by seed, the rhizomatous roots facilitate good vegetative spreading as well.

Ecological Setting

Found on sandy prairie sites and in open woods; and commonly on sand dunes (312). In Wyoming, found in areas where topsoil is normally absent and associated with plants such as Oryzopsis hymenoides, Artemisia cana, Chrysothamnus spp., and Yucca glauca (381). On the grasslands of eastern North Dakota, sand grass grows on the excessively drained "high prairie" in association with needle-and-thread (Stipa comata), june grass (Koeleria cristata) and side oats grama (Bouteloua curtipendula) (469). It is well adapted to sites that receive 30 cm of precipitation annually (90, 639), but the range of 25 to 40 cm seems satisfactory (426).



TOLERANCES

Soil Preferences

Associated with sandy soil conditions (312). In Montana, sand grass grows on soils of medium to coarse texture (1). In the mountains of Montana and Wyoming, sand grass prefers dry habitat, with an optimum slope of 9 to 30% and an optimum soil depth of more than 65 cm. Growth is good on sandy soil, fair on loamy soil, and poor on clayey soil.

Nutrient Requirements

Responds to nitrogen fertilization, but will grow on low fertility soils.

Soil Reaction

Generally occurs on neutral soils, but will tolerate somewhat alkaline sites.

Soil Salinity

Not found on saline soils.

Drought

Sand grass is rated as drought hardy (183, 426). In Montana mixed prairie conditions, field studies indicated greater water infiltration and higher soil water content under sand grass colonies than under surrounding vegetation; greater snow catch has been noted as well (1). It tends to replace sand bluestem (Andropogon hallii) on the American great plains during drought periods.

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Sand grass is associated with the relatively unshaded conditions of sand dunes and open prairie.

Grazing or Mowing

Sandgrass disappears under high grazing intensities and is considered a "decreaser" relative to other range plants (1). The species is therefore considered moderately sensitive to heavy grazing.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Rated high for erosion control value (405); it is treated as a sand binder (199), effectively stabilizing sand dunes (482). The surface roots are dense and wiry, and are well adapted to holding sandy soil against wind erosion (9).

Adaptation to Disturbance

Despite its heavy root development, sand grass is susceptible to trampling and will disappear from sites where livestock congregate (9). It is adapted to disturbed or shifting soil conditions (439). Noted to invade sand dunes as a pioneer (482).

Competitive Ability

Good stands of sand grass ("Goshen") were obtained when grown in mixtures with "Critana" thickspike wheatgrass, "Rosanna" western wheatgrass, green needlegrass or Indian ricegrass (1). It is apparently aggressive, sometimes occurring in pure stands of small size (1).

Commercial Value

Erosion control (405).

Palatability and Nutritive Value

Sand grass is palatable for livestock during its first month of growth (in the spring) and after it cures on the stem in the autumn. It is also considered a good winter pasture species. However, stems are rarely eaten if other food is available (9). Sand grass is a high producer (1). Forage value for mule deer and game birds is poor, but for small mammals it is considered fair (447).

Seed or Planting Stock Availability

Little commercial production; certified seed is apparently not available in Canada at present, although seed of the species has been distributed for field testing (183). "Goshen" is licensed in the U.S. (639) and is available in quantity, though at relatively high cost. Approximately 273 000 seeds/lb (639).

Methods and Ease of Establishment

Best establishment would be by seeding, though commercial seed is not yet available in Canada (183). Spring seeding is recommended at a rate of 3 to 4 lbs PLS/ac (639).

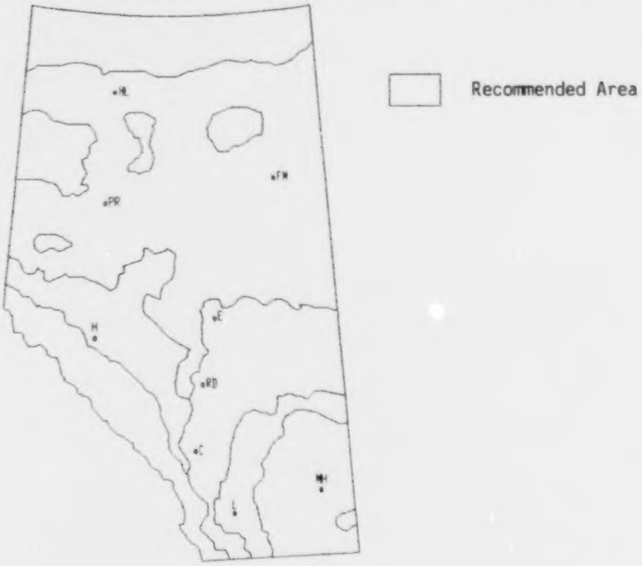
Current Status for Reclamation

Calamovilfa longifolia has been released recently as a licensed variety ("Goshen") by the U.S. Soil Conservation Service for stabilization and range revegetation on sandy soils (456). Sand grass is in limited use in North America, but most work to date is experimental. First year results are available for experimental pipeline berm revegetation in northeastern B.C. Survival of transplanted nursery stock has been about 60% (431).

The species has been recommended for testing in the Alberta foothills and mountains (435), and would seem to warrant experimentation for tailings sand stabilization in the Alberta oil sands. Its primary assets are its soil binding abilities, its adaptability to sandy soils, its drought tolerance, and its modest nutrient requirements.

Carex atherodes

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid				X	
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Wet to moist.				
Soil Preference	Clay to clay loam.				

Carex atherodes Spreng.

SPECIES BIOLOGY

Taxonomy - Awned Sedge (98)

Also C. trichocarpa var. aristata

Origin and Range

Native. Ontario to the Yukon, south to New York, Indiana, Missouri, Colorado, Utah and Oregon. Also in northern Eurasia (503).

Growth Habit

A large water sedge which grows in clumps to 100 cm high. Awned sedge has heavy scaly rhizomes 4 to 6 mm in diameter (502). It is a very coarse-growing sedge (78); basal sheaths are purplish.

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Primarily by rhizomes. Seeds are often sterile.

Ecological Setting

Awned sedge is a common species in shallow fresh water marshes, sloughs and wet meadows throughout the prairies (312). It is often found growing with beaked sedge (Carex rostrata) in western Colorado (98). In western North America it is usually found between 1 670 and 2 830 m ASL (503). It is abundant in the grassland and parkland zones of the prairies, often forming solid stands in slough bottoms (502).

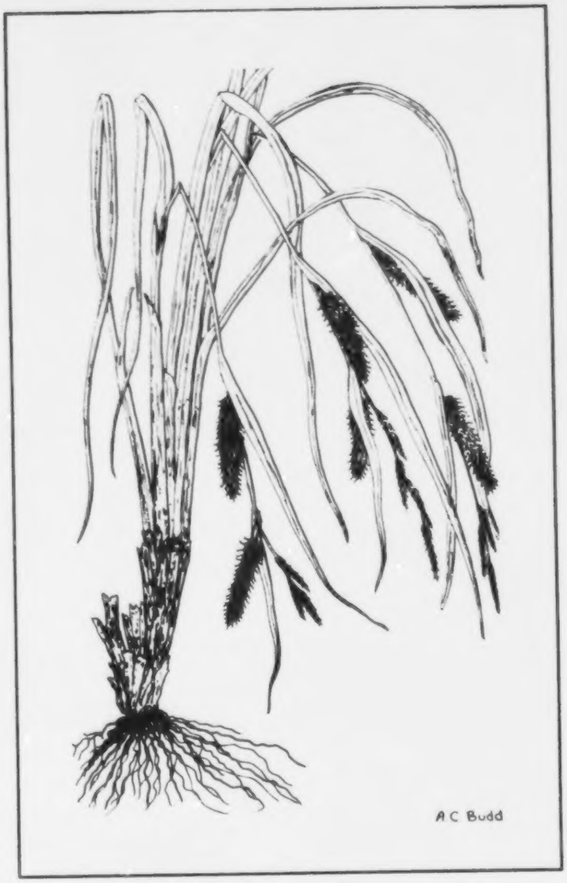
TOLERANCES

Soil Preferences

Awned sedge is characteristic of wetland sites. It has been reported growing in sloughs with soil textures of clay and clay loam. One known site had 30 to 60 cm of peat over the clay (98).

Nutrient Requirements

Grows on relatively nutrient rich sites, hence nutrient requirements expected to be moderate to high.



Soil Reaction

Mildly acidic to moderately alkaline.

Soil Salinity

Will tolerate moderately saline soils.

Drought

Awned sedge can apparently tolerate drying up of sloughs more than Carex aquatilis or C. rostrata which are more commonly found in continuously wet sites (502).

Heavy Metals and Hydrocarbons

No specific tolerances noted in the literature reviewed.

Shade - Does not tolerate shade.

Grazing or Mowing

Two mowings per year was found to be the optimum for maintaining yield and chemical composition of awned sedge. Mowing six times in one growing season reduced the forage yield of that year and the following year, but it did not alter the chemical composition of the forage (98).

Susceptibility to Disease and Insect Damage

No pests noted in literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Extensive rhizome system and prolific growth makes awned sedge a good soil stabilizer, and adds significantly to the organic matter of the soil.

Adaptation to Disturbance

Observed to survive, and seems to thrive on burned sites or sites disturbed by moose.

Competitive Ability

Very aggressive due to rhizomatous habit.

Commercial Value

Awned sedge and beaked sedge are valuable species for hay if cut early (98). Used as cover by waterfowl and semi-aquatic mammals.

Palatability and Nutritive Value

The chemical composition of awned sedge was found to be similar to that of meadow grasses, upland short grass, and mixed prairie species. Seasonal declines in crude protein, phosphorous and carotene were also similar to that of native upland grasses. Crude protein ranged from 18.7% in May to 8% in September (98).

Seed or Planting Stock Availability

No commercially available seed. Awned sedge is abundant and its seed is easily collected. However, low germination rates and the lack of pre-treatment knowledge has hindered the development of seed stocks.

Methods and Ease of Establishment

Thought to do well from rhizome cuttings or transplanting.

Current Status for Reclamation

Not currently used for reclamation, although holds promise for revegetation of wetlands and drainage ditch banks.

Carex rossii

SPECIES SUITABILITY MAP AND SUMMARY TABLE

HL
FM
PR
E
H
RD
C
MH
L
☐ Recommended Area

Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance	X				
Salt Tolerance				X	
pH Tolerance Acid			X		
Base				X	
Winter Hardiness		X			
Erosion Control		X	X		
Persistence		X			
Palatability		X	X		
Browse Tolerance	X	X	X		
Moisture Preference	Dry.				
Soil Preference	Sandy loam to clay loam compacted and unstable slopes.				

Carex rossii Boott.

SPECIES BIOLOGY

Taxonomy - Ross's Sedge (47)

Origin and Range

Native. British Columbia and the Yukon, south to South Dakota, Wyoming, Colorado, and Arizona and California (503).

Growth Habit

A small sedge, usually in dense tufts, 5 to 30 cm high. This sedge does not have long stolons (502). The rootstocks are ascending, stout and fairly woody (312).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation - By seed and rhizomes.

Ecological Setting

Carex rossii is a common species in the aspen parkland, grasslands and dry mountain slopes. It is usually found in dry or well drained sites of aspen forests, or in clearings (502, 312). It has been reported at between 1 600 and 3 267 m ASL, on dry sites in Wyoming (18). It often grows by itself on unstable screes and steep banks.

TOLERANCES

Soil Preferences

Found on sandy loam to clay loam soils. Can tolerate excessive soil compaction as well as unstable slopes.

Nutrient Requirements

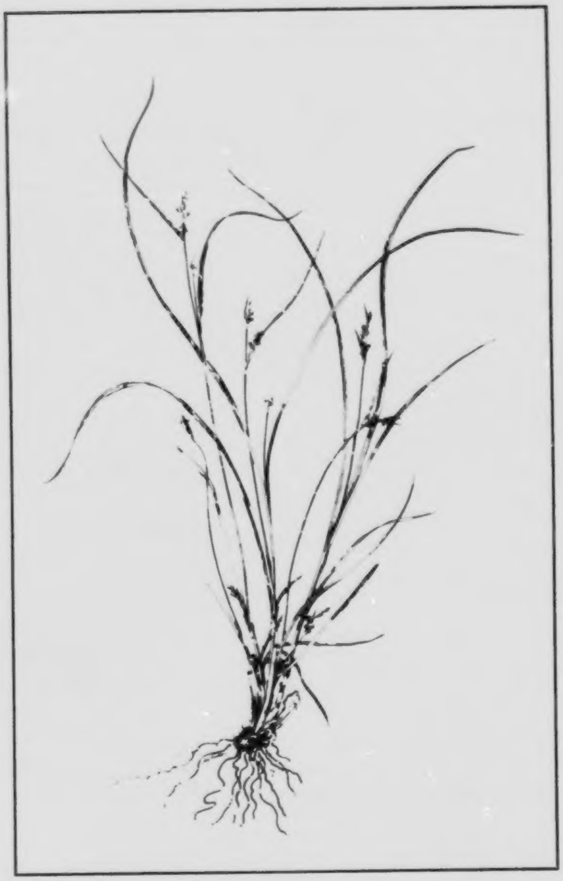
Expected to have low nutrient requirements judging by its natural occurrences.

Soil Reaction

Prefers mildly alkaline to moderately acidic soils.

Soil Salinity

Will tolerate mildly saline soils.



Drought

Found on sites prone to excessive drought.

Heavy Metals and Hydrocarbons

No specific tolerances noted in the literature reviewed, but noted to survive on fuel oil saturated soils in southeastern B.C.

Shade - Will tolerate at least partial shade.

Grazing or Mowing

Grazed by bighorn sheep, elk and deer (144), with little damage. The low matting habit and extensive root system is expected to allow this species to withstand moderate to severe grazing pressure.

Susceptibility to Disease and Insect Damage

No specific pests or diseases noted from the literature. Observed to be hardy in native sites.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The extensive root system and the ability to contend with unstable loose material as well as compacted soils makes this species an excellent soil builder with good erosion control capability.

Adaptation to Disturbance

Invades extremely hostile, disturbed sites in southeastern B.C.

Competitive Ability

Aggressive as a pioneer of hostile sites.

Commercial Value

Utilized as domestic sheep forage in the Rocky Mountains and Colorado basin (503).

Palatability and Nutritive Value

Sedges have been reported to be highly preferred by bighorn sheep and moderately preferred by elk, mule deer and moose (144). Ross's sedge has been rated as having fair to good forage value for sheep (503).

Seed or Planting Stock Availability

No commercially available sources of propagules.

Methods and Ease of Establishment

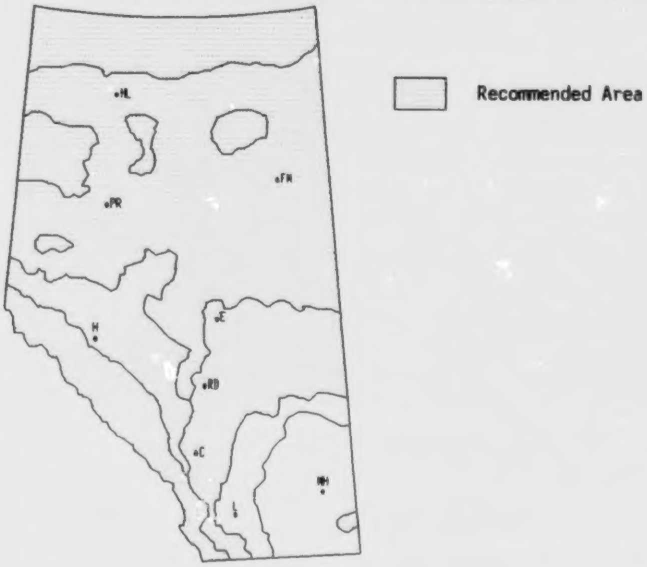
Seed may be difficult to collect and may have low viability. Splitting and transplanting of native clumps may prove an effective means of establishment. Research required to determine most suitable method(s) of establishment.

Current Status for Reclamation

Not currently employed in revegetation programs in Alberta. Some small scale testing of this species has been conducted in southeastern B.C.

Dactylis glomerata

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid			X		
Base				X	
Winter Hardiness		X	X		
Erosion Control			X		
Persistence	X	X			
Palatability		X			
Browse Tolerance		X			
Moisture Preference	Moist to wet, tolerates some flooding.				
Soil Preference	Moderately coarse to medium textured, well drained.				

Dactylis glomerata L.

SPECIES BIOLOGY

Taxonomy - Orchard Grass.

Origin and Range

Introduced. Originated in Eurasia (199), notably from central and western Europe (183). It has escaped in favorable locations (47, 312). In North America, the species is extremely widespread, occurring from Newfoundland to Florida, and California to Alaska (199). It is best adapted to more humid regions such as the eastern edge of the plains (183).

Growth Habit

This is a tall, tufted bunchgrass, which often occurs in tussocks (199, 47). It is coarse and leafy (312, 391). Cultivars and varieties vary in height from about 60 cm to 120 cm (199); a dwarf variety "Pomar" is usually less than 60 cm tall (183). Typical heights for locally available cultivars are 65 to 80 or 90 cm (139, 341). Roots are medium sized and fibrous (179, 47).

Nitrogen Fixing - None

Longevity

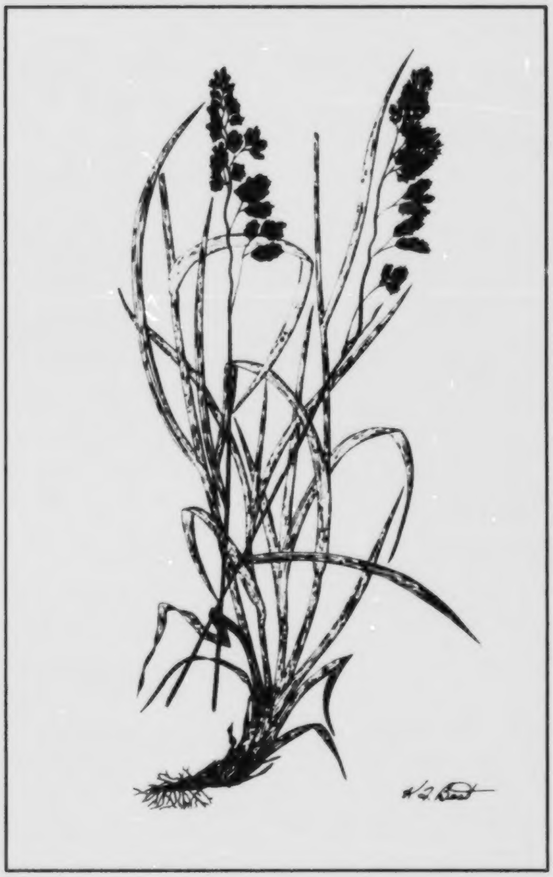
Orchardgrass is a long-lived, cool season (712) perennial (179). The species is subject to winterkill, though some cultivars are notably more winter hardy than others (391, 183, 139). More subject to winterkill than timothy (Phleum pratense), slender wheatgrass (Agropyron trachycaulum), or smooth brome (Bromus inermis) (183, 359).

Self Propagation

Self propagation is primarily by seed, though at least one cultivar spreads vegetatively from abundant tillers (183, 391, 339). Seeds germinate quickly and seedlings are vigorous (391). Seed production is excellent (339). Plants spread rapidly from seed (340, 339).

Ecological Setting

Occurs in moist or irrigated hay or pasture areas (341, 183), as well as under orchard trees (47, 179), including on slopes. It is also found in fields, meadows and waste places (199). Adequate moisture is necessary, over 30 to 45 cm (179, 339). It is successful locally in irrigated or higher precipitation areas throughout the mountains and dry intermountain regions (183). Favors subhumid climates (179). Performs well at high elevations (2 000 to 2 600 m ASL) in northern Utah; plants remained vigorous and produced an abundance of high quality forage (406). "Latar" appears to do best on protected sites which are snow covered in winter, even at elevations to 3 500 m ASL in Colorado (357). "Tardus" performed well in trials at Tent Mountain (2 100 m ASL) (29). "Chinook" noted as long-lived (30 years) in the southern foothills of Alberta (D. Walker, pers.comm.).



TOLERANCES

Soil Preferences

Orchardgrass is best adapted to medium textured, well drained, fertile soils. Growth may also be good on moderately coarse textured soils (179). The species will tolerate some flooding but not as much as reed canary grass (Phalaris arundinacea). Survives on wet soils (391).

Nutrient Requirements

Persists on relatively shallow, infertile soils, but shows good response to improved fertility (500). Reported to prefer fertile soils (179). Does well in combination with leguminous species (179).

Soil Reaction

Performs well on moderately acid, neutral or mildly alkaline soils (179). A lower limit of pH 4.5 has been suggested for the eastern US (712).

Soil Salinity

Prefers calcareous soils (179); shows fair tolerance to salts (424), in the range of 4 to 8 mS/cm (247).

Drought

More drought tolerant than either timothy or Kentucky bluegrass (Poa pratensis) (391), but cannot be considered better than moderate (340). "Barge", "Dayton", "Napier", "Palestine" (Reg. No. 7), and "Pomar" comprise the more drought resistant cultivars (183).

Heavy Metals and Hydrocarbons

Reported to be intolerant of toxic boron spoils (5 ppm soluble boron) with an electrical conductivity of 10 mS/cm and a sodium saturation of 30% (344). No other tolerances or sensitivities were noted from the literature.

Shade

Highly shade tolerant, growing very well under deciduous tree cover (340, 339).

Grazing or Mowing

Excellent tolerance to grazing (339).

Susceptibility to Disease and Insect Damage

Some strains susceptible to leaf disease (Mastigosporium rubricosums (Dearn. and Barth.) Sprague, rust leaf blight and leaf streak. Several resistant cultivars are available (183). Overall resistance to disease and insects is considered excellent (339).

RECLAMATION CONSIDERATIONS

Adaptation to Disturbance

Presumably orchardgrass is fairly well adapted to disturbance (in subhumid areas) as it germinates rapidly, has vigorous seedlings and shows excellent natural spreading ability (391, 339).

Competitive Ability

The species is only moderately aggressive and can be considered compatible with others (339). It is often used with smooth brome, or with such legumes as alfalfa (Medicago spp.), white clover (Trifolium repens), and birdsfoot trefoil (Lotus corniculatus) (179).

Commercial Value

Important for forage, hay and silage (183, 179). "Pomar" is used for cover and erosion control under orchards (forest cover) (179). The variegated form, var. variegata, is used as an ornamental (199). Limited current use in mined land reclamation (426).

Palatability and Nutritive Value

Excellent palatability (340, 339, 19, 427). Wildlife and livestock seek orchardgrass in all seasons, but it is particularly attractive in spring as the snow recedes, because basal leaves remain green throughout the winter and new leaves appear quickly (339). Hay and forage is high quality, and when planted with legumes (a common practice), hay quality is exceptionally good (179). Nitrogen content remains high through the summer (406).

Seed or Planting Stock Availability

Numerous commercial cultivars are available. These have been developed in, and are adapted to, many countries and regions including Canada, the U.S., France, Poland, Germany, Denmark, Sweden and Wales (90, 183). Canadian-bred cultivars include "Chinook", "Hercules", "Frode", "Kay", and "Rideau" (139, 183). These are more winter hardy and are earlier maturing (183). These and "Hallmark", "Ina", "June", "Majestic", "Nordstern", "Pennulate", "Sterling", "Sumas", "S-143", and "Tardus II" are licensed in Canada (138). Approximately 654 000 seeds/lb (639).

Methods and Ease of Establishment

Establishment is usually by seed, though good transplanting success can be expected (339). Seeding has fairly good expectations for success, since germination is rapid, seedling vigor is good, and growth rate is excellent (391, 339). A seeding rate of 10 to 20 lbs PLS/ac has been recommended for the eastern US (712), but only 2 to 3 lbs PLS/ac in a spring seeding for the west (639). Planting in combination with other grasses, and especially with legumes, is recommended since nutrient requirements are moderate and forage quality can be improved in this way (179). The dwarf cultivar "Pomar" has reduced maintenance requirements under orchards due to its shorter stature. Seed retains its viability above 80% during 12 to 14 years of cool, dry warehouse storage (179). Viability of 29% has been recorded after 20 years (211).

Current Status for Reclamation

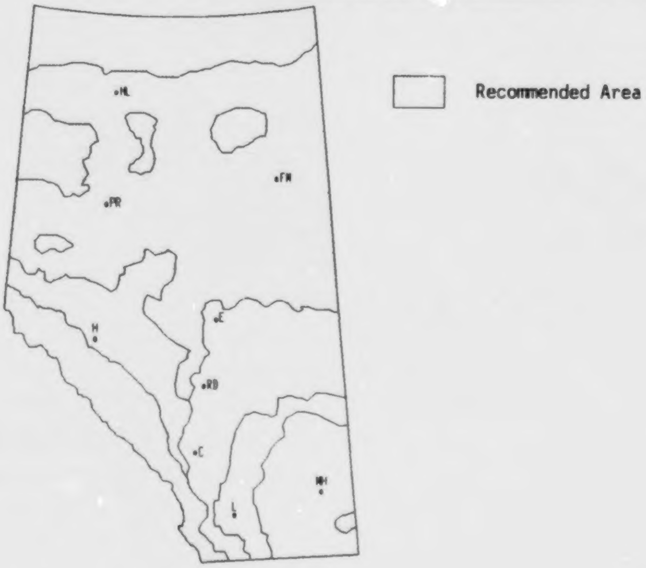
Orchardgrass has been tested, with good success, on high elevation overburden at Tent Mountain, and on Harmer Ridge near Sparwood, B.C. (380, 498, 494). Results show that growth is very good between 1 500 and 1 900 m ASL in southeastern British Columbia (498). Trials have also been carried out at Luscar, Alberta (144), near Grande Cache (377) and at Inuvik and Tuktoyaktuk, N.W.T. (195). Under the latter cold conditions, germination is good, but overwintering success is poor (195).

Orchardgrass is fairly widely used for rehabilitation work in the United States, particularly in the more humid eastern states. Experimental work has been done at a coal test pit near Roundup, Montana (129), at the Decker mine (with poor success (117)), and on the Beartooth Plateau (74). Experimental and propagation efforts are active in Oregon (130, 266), Idaho (147), Colorado (236, 132), Utah (406), Arizona (354), and Texas (375). Results at high elevations are encouraging, but drought appears to be a major factor limiting success.

Orchardgrass is widely used, in subhumid climates and under irrigation, as a pasture and hay crop. It is also used for erosion control in orchards or under other forest cover (179). It has been used with varying, but generally limited, success for reclamation. Overall, where moisture is adequate prospects are good. Its chief assets are its tolerance to acidic conditions, its ease of establishment through seeding, and its tolerances of shade, grazing and flooding. It is highly palatable and nutritious, long-living and is a good soil builder and stabilizer. It is relatively intolerant of drought, however, and requires moderate fertility.

Deschampsia caespitosa

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance				X	X	
Salt Tolerance				X	X	
pH Tolerance	Acid		3.3			
	Base			X		
Winter Hardiness		X	X			
Erosion Control			X	X		
Persistence				X		
Palatability				X	X	
Browse Tolerance				X		
Moisture Preference		Wet to moist.				
Soil Preference		Medium to fine textured, tolerates wide range.				

Deschampsia caespitosa (L.) Beauv.

SPECIES BIOLOGY

Taxonomy - Tufted Hair Grass

Origin and Range

Native. Alaska to Greenland, south through most of the United States and northern Mexico. Also found throughout Eurasia (507). *D. caespitosa* forms hybrids with *D. beringensis* and *D. brevifolia* in Alaska (214). A highly complex and variable species (214). Tufted hair grass is common throughout the prairie and mountain regions of Alberta (312).

Growth Habit

Tufted hair grass is a tall, densely tufted bunchgrass, (426) 20 to 120 cm tall. There are apparently large differences between various populations in cold hardiness.

Nitrogen Fixing - None

Longevity - Cool season (639) perennial (426).

Self Propagation

Propagates itself only by seed.

Ecological Setting

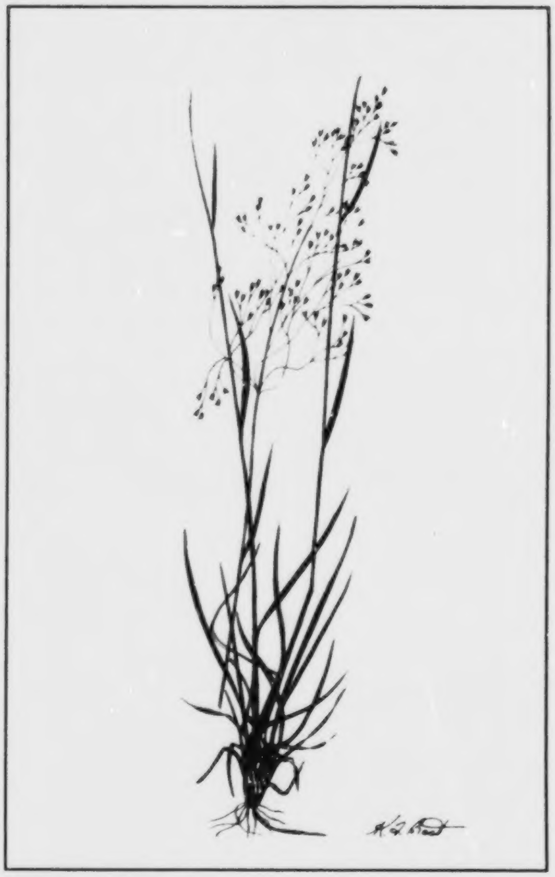
It is found in sloughs, moist draws, wet meadows and on stream banks (312, 78). It occurs on wet or damp sites at elevations of 2 300 to 4 260 m ASL and occasionally as low as 1 600 m in the western United States. It is usually found on moist meadows. Requires 50 cm of precipitation (639). Ecotypes perform well on dry, windblown disturbed sites at high elevations (426). It has been reported as a dominant species on alpine/subalpine meadows in southwestern Montana (193).

TOLERANCES

Soil Preferences

Tufted hair grass is adapted to wet sites, at optimum slopes of 9 to 30% and optimum soil depth of 30 to 60 cm. Growth on sandy soil is rated as fair, and on loamy and clayey soil as good (446). It has been reported growing on coarse textured river alluvium in northern Alaska (52).

Nutrient Requirements - Unknown



Soil Reaction

Tufted hair grass has been observed as a dominant colonizer of calcareous mine waste materials (387). It is also a pioneer on acid soils near Sudbury, Ontario. It grew well on tailings of pH 3.3 (246).

Soil Salinity

Probably not well adapted to very saline sites.

Drought

Some ecotypes are presumed to be at least moderately drought tolerant, though the species prefers moist locations.

Heavy Metals and Hydrocarbons

Tufted hair grass is reported to be a pioneer on acid soils with elevated levels of Ni, Cu and Co at Sudbury, Ontario. Cu, Ni and Zn concentrations of 392, 290 and 291 ppm respectively were not toxic to tufted hair grass grown on acid tailings (pH 3.3) in a greenhouse experiment. It also grew well on near neutral tailings with concentrations of Pb to 2 300 ppm, Zn to 18 000 ppm, Cd to 114 ppm, Cu to 1 420 ppm and As to 50 000 ppm (246).

Shade

Likely at least moderately tolerant of shady locations

Grazing or Mowing

Tufted hair grass has moderate tolerance to grazing (639).

Susceptibility to Disease and Insect Damage

Tufted hair grass is rated as having good resistance to insects and disease (339).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Tufted hair grass has a medium rate of growth but has a poor rate of spread. It is considered fair for soil stabilization (339). Tufted hair grass produces considerable ground cover (436).

Adaptation to Disturbance

Tufted hair grass has been observed growing in disturbed sites in the alpine in Colorado (177). Tufted hair grass is a pioneer on river alluvium in northern Alaska (52). It also colonizes acid spoils near Sudbury, Ontario (246). Tufted hair grass is occasionally found as a pioneer on dry gravel bars near Golden (1 900 m ASL), B.C. (209).

Competitive Ability

Tufted hair grass has been rated as having good compatibility (436). It has good competitive ability relative to a number of plant species considered for the Alaska Highway gas pipeline revegetation (223). Based on field observations, it is presumed to be no more than moderately aggressive, in relation to other plants within its range.

Commercial Value

This grass is a valuable soil stabilizer, especially in wet, acidic locations. It is also important for wildlife forage.

Palatability and Nutritive Value

Tufted hair grass is a leafy and palatable grass (426, 427). It has been rated as good for providing palatable early spring growth and remains palatable through summer growth (339). Forage value has been rated as fair for mule deer and game birds, and good for small mammals. Cover value has been rated as poor for mule and game birds, but good for small mammals (446). Frequently grazed by bears.

Seed or Planting Stock Availability

Tufted hair grass is not available from commercial sources (426). Apprxoimately 2 500 000 seeds/lb (639)

Methods and Ease of Establishment

In Utah, tufted hair grass is easily established from seed, though seed is not particularly abundant. Germination is fair, but initial establishment is often poor. Ease of transplanting has been rated as good (339). Good seed production from a strain of tufted hair grass (M-926) has been reported (131). Tufted hair grass has been successfully transplanted to disturbed alpine/subalpine sites in Montana (74). Fall seeding is recommended at a rate of 1 to 2 lbs PLS/ac (639).

Current Status for Reclamation

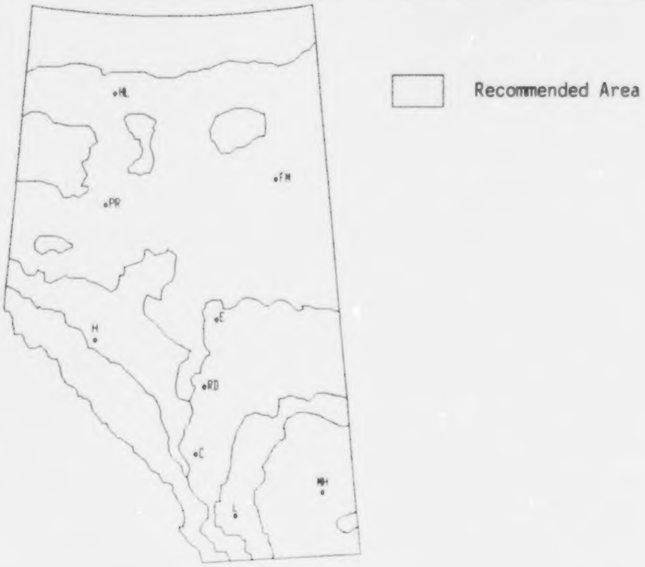
This species has potential for use in reclamation in Alberta. When planted at several alpine and subalpine sites in the Rocky Mountains in Alberta, it had excellent survival and cover after five years (723), however performance in mixed seedings was poor after six years (705). Plant cover was significantly higher on overburden topdressed with mineral soil than on raw overburden (364). Survival and vigor was good on medium textured soil and poor on fine-textured soil after three years testing in the Upper Mackenzie region of the boreal forest (latitude 63° N) (644). It was found to be highly tolerant of metal contaminated tailings (Pb, Zn, Cu, Mn) in the Yukon (611). At Fort McMurray, tufted hair grass had relatively low cover after five years on tailings sand soil mixtures (705).

Three varieties of tufted hair grass (Deschampsia caespitosa/beringensis complex) are currently undergoing seed increase and other testing at Palmer, Alaska (223). Tufted hair grass has been recommended for revegetation of disturbed areas in moderately moist to moist regions in northwestern Colorado (427). It is a promising species for revegetation of bare soil in the alpine in Colorado (323).

This species is adapted to moist to wet sites throughout the prairies, moist mountain meadows and somewhat alkaline as well as relatively acidic soils. Some populations are also adapted to growing on spoils with elevated levels of heavy metals.

Distichlis stricta

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance	X				
pH Tolerance Acid					
pH Tolerance Base		X			
Winter Hardiness			X		
Erosion Control	X				
Persistence		X			
Palatability				X	
Browse Tolerance					
Moisture Preference	Occassionally dry.				
Soil Preference	Medium to fine textured, poorly drained.				

Distichlis stricta (Torr.) Rydb.

SPECIES BIOLOGY

Taxonomy - Alkali Grass (78); Inland Saltgrass (639).

Also D. spicata (L.) Greene var. stricta (Gray) Beetle

Origin and Range

Native to North America. Occurs throughout the Canadian prairies, to eastern Washington, California, Texas and much of the American dry interior. Also in Mexico (430, 47).

Growth Habit

Low, extensively creeping, sod-forming grass (312, 78). Erect or decumbent (312). Extremely aggressive scaly rhizomes, sometimes with stolons (426, 47).

Nitrogen Fixing - None

Longevity - Warm season (639) perennial (47, 312).

Self Propagation

Dioecious (426, 78, 312). Very poor seed production (426). Aggressive vegetative spreading by rhizomes and stolons (47, 78, 426).

Ecological Setting

Commonly occurs in lowlands (264) and where sites are wet and drainage is poor. Also on so-called sub-irrigated lands which are subject to alternating dry and wet periods (426). Requires 20 cm of precipitation (639). Generally occurs on saline or alkaline sites; occasionally on dry slopes (47, 199, 312).

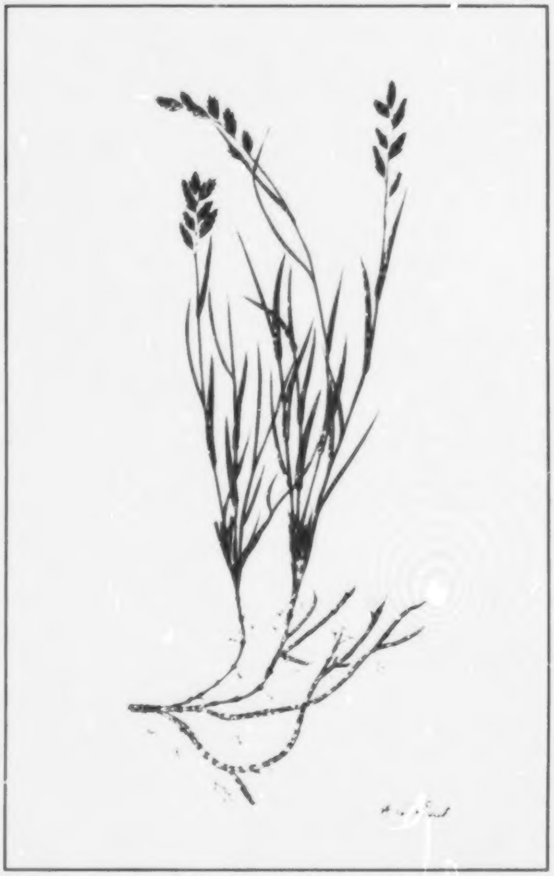
TOLERANCES

Soil Preferences

Soils are usually saline or alkaline, often Solonetzic, and may include silty and loamy materials through to clays (316, 230, 264). Sites are often intermittently wet and dry (426).

Nutrient Requirements

Saltgrass meadows typically have low fertility (264); requirements are therefore presumed to be modest.



Soil Reaction

Well adapted to alkaline soil conditions (47, 264, 426).

Soil Salinity

Considered to have very high tolerance to saline conditions, possibly above 16 mS/cm (361, 469). It is reported by others to withstand 2% salt and electrical conductivity in the range of 24 mS/cm (468).

Drought

Saltgrass is distributed on very dry upper slopes and ridge tops at Estevan (230) and apparently withstands intermittent drought (426).

Heavy Metals and Hydrocarbons

No particular tolerances or sensitivities were noted from the literature consulted.

Shade

No specific information, but based on normal habitat, saltgrass is presumed to be relatively shade intolerant.

Grazing or Mowing

The species is not grazed extensively, nor is it often mowed, but its rhizomatous habit suggests it would withstand such pressure well.

Susceptibility to Disease and Insect Damage

No information is available from the literature consulted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Saltgrass is considered an outstanding species for wind or water erosion control (426) due to its extremely strong rhizomatous growth habit. In fact, it is difficult to eradicate except by spraying (264).

Adaptation to Disturbance

The species is persistent even where mechanical means are used for eradication (264). Though seed production is low, rhizomes can be expected to cause colonization of all suitable sites adjacent to established stands.

Competitive Ability

Saltgrass is expected to be an extremely strong competitor on suitable alkaline or saline sites.

Commercial Value

Major usefulness for stabilization of extremely saline or alkaline sites, and for maintenance of an erosion controlling ground cover (426).

Palatability and Nutritive Value

Though the species may be palatable (and grazed) in spring when it is green (426), or where palatable species are generally lacking, it is generally considered unpalatable (132, 264).

Seed or Planting Stock Availability

Commercial seed is not available due to poor natural seed production capability (426). Colorado State University Horticulture and Botany Departments are putting some effort into breeding and improving seed (132). Small quantities of seed can now be obtained from dealers in Idaho. Approximately 520 000 seeds/lb (639).

Methods and Ease of Establishment

Transplanting or sprigging would probably be effective establishment methods, based on knowledge of natural habits. Seeding may also be effective, but since seed is not generally available, a seeding program may prove costly. Summer seeding at a rate of 10 lbs PLS/ac has been recommended (639). Planting alone may encourage grazing, and would facilitate management (426).

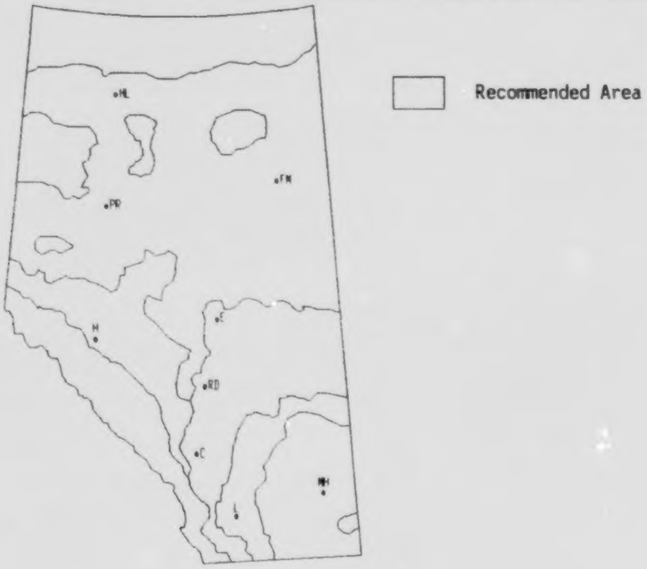
Current Status for Reclamation

The species is found naturally, particularly in lowland saline or alkaline sites (264, 230). It is also a volunteer on saline mined land refuse, particularly in the Estevan area of Saskatchewan (316). It is considered an encouraging species for special purposes at high altitudes (132) and in mined land reclamation (426).

The species appears to have excellent adaptation to certain troublesome site situations (salinity, alkalinity, and intermittent wet and dry periods), but is hampered in its usefulness by poor seed availability.

Elymus innovatus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid				X	
pH Tolerance Base				X	
Winter Hardiness		X	X		
Erosion Control		X	X		
Persistence			X		
Palatability		X		X	
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Coarse to fine textured, well drained.				

Elymus innovatus Beal

SPECIES BIOLOGY

Taxonomy - Hairy Wild Rye

Origin and Range

Native. Grows from Alaska to the Red River in Manitoba, and southward into Montana, North and South Dakota, Idaho and Washington. In Alberta, it occurs within the Parkland and northward, in the Cypress Hills, and throughout the lower ranges of the Rocky Mountains (506). Hybridizes with *Agropyron dasystachyam*, *A. smithii* and *A. trachycaulum* (312).

Growth Habit

Tall, erect sod-forming grass, with slender scaly rhizomes (365). Usually 100 cm or more in height. Noted for its deep and spreading root system (507).

Nitrogen Fixing - None

Longevity - Perennial grass (405).

Self Propagation

Seeds and creeping rhizomes. Noted for abundant seed production (453). Noted for poor seed set (D. Walker, pers.comm.).

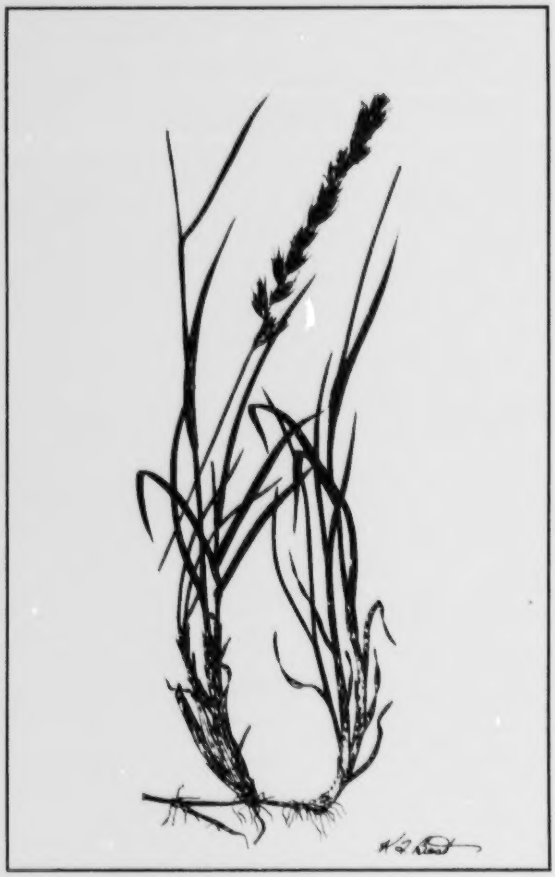
Ecological Setting

Very common in open woodlands, especially in pine forests of western Alberta (312), up to the mid-subalpine (209), to at least 1 400 m (214). Rare in the south but more abundant in the north (47). Noted as an indicator species of *Pinus*/*Picea glauca*/*Arctostaphylos uva-ursi* association (edaphic climax) on well drained sand dunes in Alberta (253, 258). Also found growing on glacial outwash in Alaska (209).

TOLERANCES

Soil Preferences

Associated with sandy soil (214). It develops dense stands under open poplar and pine stands where the soil is sandy or gravelly (453). Provides ground cover on coarse textured soils in the Peace River parkland region and on coarse to fine textured soils in the boreal mixed wood region (435).



Nutrient Requirements

Responds to nitrogen fertilization, although it grows well on low nutrient soils.

Soil Reaction

No tolerances noted in the literature, but expected to be tolerant of mildly acidic to mildly alkaline soils.

Soil Salinity

Presumed to be tolerant of mildly saline soils.

Drought

Does best where the probability of drought is low.

Heavy Metals and Hydrocarbons

Hairy wild rye provided good growth in initial growth chamber tests on lean oil sand, heavy oil sand, and soil mixes with variable oil content (404, 209). Other tolerances not known.

Shade

Associated with forest openings, and is presumably relatively shade tolerant.

Grazing or Mowing

Generally not eaten. Expected to be moderately tolerant of mowing.

Susceptibility to Disease and Insect Damage

Seed heads often develop rust infections, especially in wet years.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Hairy wild rye colonizes disturbed areas rapidly and, along with its deep and spreading root system, acts to reduce wind and water erosion (453). Regarded as a good sand binder (258).

Adaptation to Disturbance

Will readily invade disturbed sites in adapted area. Often a pioneer on such sites (453).

Competitive Ability

Noted for establishing quickly on all sites cleared of poplar (Populus spp.) and jackpine (Pinus banksiana) (506).

Commercial Value

Erosion control and soil stabilization.

Palatability and Nutritive Value

Not palatable and will not be eaten by cattle if other grasses are available (47, 506). The coarse leaves and stems are not succulent at any time, and the hairiness probably discourages consumption (506). However, hairy wild rye has been identified as one of the most valuable native forage plants (435), presumably where more palatable species are absent. It accumulates nitrates to poisonous levels if over-fertilized, and therefore must be used with caution (D. Walker, pers.comm.).

Seed or Planting Stock Availability

Not commercially available. Several chromosome races occur, some of which produce sterile progeny (D. Walker, pers.comm.).

Methods and Ease of Establishment

Spring seeding of E. innovatus on reclaimed pipeline berms in north-eastern British Columbia resulted in 50% germination and survival (431). Transplanting sod clumps of hairy wild rye has proved successful for sand dune reclamation in Alberta, although the technique appears costly (258). The very hairy seeds of hairy wild rye could cause problems in a seed drill or broadcast seeder (455).

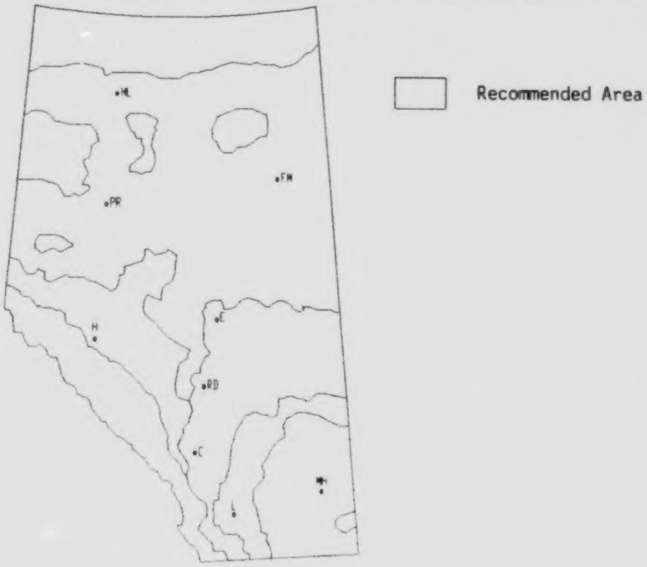
Current Status for Reclamation

Hairy wild rye is a native grass which is abundant in most forested areas of Alberta. Growth trials using local seed sources of hairy wild rye indicate good growth on coal mine spoil in the Rocky Mountain foothills of Alberta (271). It is being tested for pipeline revegetation in arctic and boreal regions of North America (298). It is currently under investigation at the University of Alberta for high elevation revegetation and wildlife range improvement uses (453).

It is an abundant seed producer, facilitating field collection and harvesting of seed. It is well adapted to sandy soils, has apparent tolerance to bitumen materials, and preliminary growth trials indicated potential suitability for oil sands revegetation (particularly where establishment of native species is desired). It also appears useful for revegetation in the mountains and foothills (453). Drawbacks include limited field experience defining applied uses and conditions for reclamation suitability, and limited wildlife forage value. It may be useful along highways where wildlife use is to be discouraged.

Elymus junceus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance		X			
pH Tolerance Acid				X	
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control			X		
Persistence		X			
Palatability	X	X			
Browse Tolerance		X			
Moisture Preference	Dry to moist.				
Soil Preference	Sandy to clayey.				

Elymus junceus Fisch.

SPECIES BIOLOGY

Taxonomy - Russian Wild Rye

Origin and Range

Introduced. Originates from western Siberia (138). Used as a pasture crop throughout the prairie area of western Canada (138), and throughout much of the western United States.

Growth Habit

A tall, densely tufted, deep rooted bunchgrass. Mature plants stand 90 to 120 cm tall.

Nitrogen Fixing - None

Longevity

Long-lived, cool season (639) perennial (391) bunchgrass.

Self Propagation

Seed. No vegetative reproduction. A good natural reseeder (335).

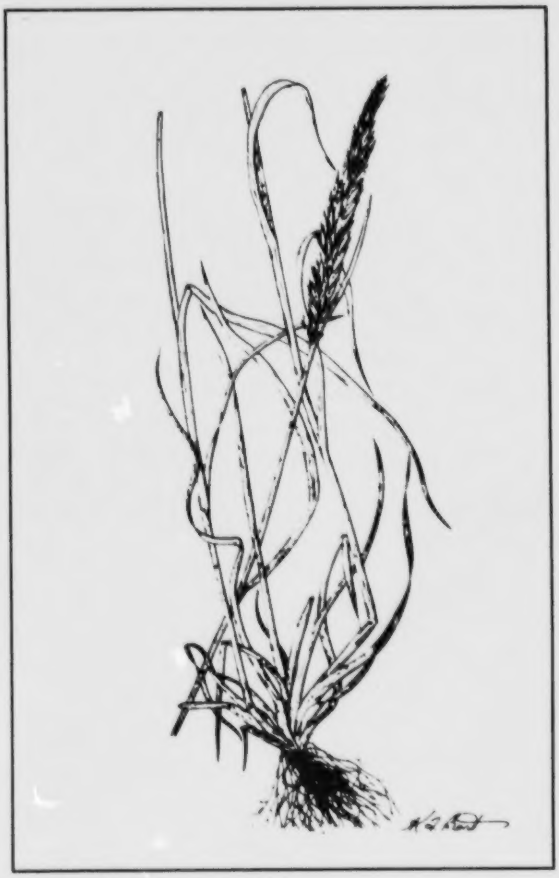
Ecological Setting

Dryland pasture lands throughout the prairie area of Canada (138). Requires 30 cm of precipitation (639). May be suitable for use on disturbed lands in the subalpine regions of Alberta (269, 209, 337); marginal success on lands at 2 070 m (380). In Colorado, Russian wild ryegrass seeded on a high elevation nursery (2 800 m ASL) maintained itself for 9 years, but had rapid decline in the tenth year (193). Generally restricted to cultivated or improved situations.

TOLERANCES

Soil Preferences

Suited for dryland pasture on loam soils (506). "Sawki" variety is noted for its adaptation to loam and clay soils on the prairies and semiarid interior of British Columbia (138). Growth trials on coal mine waste in the southern interior near Hat Creek of British Columbia demonstrated good growth on bentonitic clay materials, relative to other species tested (187). Adapted to both light and heavy soils (340).



Nutrient Requirements

In general, annual applications of fertilizer at heavy rates will provide good yields, for many years, from a single seeding (252). It is adapted to both light and heavy soils, especially those with moderate to high available nitrogen (340).

Soil Reaction

It grows well on lime bearing soils, or at least those which are basic in reaction, rather than neutral or acid (138). Rated suitable for alkaline soils (338).

Soil Salinity

Has high tolerance (11 to 16 mS/cm) to salt (125, 340, 252). A greenhouse trial of emergence in various saline solutions showed no statistically significant effects of salts up to 16 mS/cm, although emergence was considerably lower in the 16 mS/cm (691). "Sawki" noted particularly for its salt tolerance (138). On alkaline sites it is more productive than crested wheatgrass (340). Provided good growth on prairie coal mine waste with high salt content (180).

Drought

Noted for its drought tolerance (138), although small seedlings are sensitive to frost and drought (340). Emergence in soils at field capacity, "moderately dry" and "dry" was statistically similar, though better in the field capacity soils; root weight and shoot length were greater after 21 days in the field capacity soils (691).

Heavy Metals and Hydrocarbons

No information available.

Shade

Recommended for unshaded sites; it is not shade-tolerant (340).

Grazing or Mowing

Noted essentially as a pasture grass (506). Recovers rapidly after grazing when moisture is adequate; resumes growth much better after cutting than crested wheatgrass (Agropyron cristatum) or bromegrass (Bromus inermis) (252).

Susceptibility to Disease and Insect Damage

"Mayak" and "Swift" noted for their resistance to leaf-spot diseases. "Cabree" was rated better than "Sawki" in resistance to powdery mildew and spot blotch, and better than "Mayak" in resistance to leaf rust. "Piper" has moderate resistance to leaf blight and anthracnose (138).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Russian wild ryegrass showed the most successful growth in sand dune stabilization experiment in Alberta amongst species tested (258). Suitable for cultivation, though not a strong natural invader of other disturbed sites.

Adaptation to Disturbance

The sod formed by Russian wild ryegrass is extremely tough and withstands considerable abuse from trampling and driving (252). Suitable for cultivation, though not a strong natural invader of other disturbed sites.

Competitive Ability

Russian wild ryegrass does not invade adjacent areas as does crested wheatgrass (252).

Commercial Value

Essentially a pasture grass, and it should not be seeded for hay (252). Established pastures of Russian wild ryegrass have demonstrated greater beef production than native ranges in Alberta (390). Also, one of the best grasses for farmyards and lawns that cannot be watered (252). Potential erosion control value.

Palatability and Nutritive Value

Russian wild ryegrass pasture is grazed by livestock in all seasons, but is best from August to November when its protein and digestible carbohydrate contents are higher than those of other cultivated or native grasses. Cures into a very palatable hay (although difficult to cut), or cures on the stem (138). Spring seeded Russian wild ryegrass provides excellent spring and early summer pasture (391). Highly preferred by both deer and livestock.

Seed or Planting Stock Availability

Licensed varieties in Canada include "Mayak, "Sawki", "Cabree", "Swift", and "Piper" (138). Seed supplies can be purchased from most seed houses in western Canada (506). "Vinall" and "Bozoiski" are available in the US (639). Approximately 175 000 seeds/lb (639).

Methods and Ease of Establishment

The species is characterized in general by poor seedling vigor and therefore is often difficult to establish. If established under dry conditions, it may take 2 or 3 years to develop an adequate stand (391). "Cabree" variety, however, is noted for outstanding seedling vigor (138). Establishment potential by transplanting rated as good (338). Fall seeding at a rate of 8 to 10 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

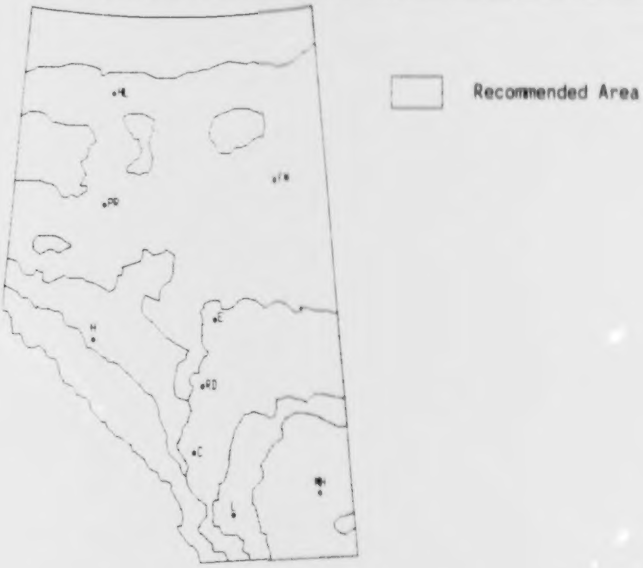
Experience with Russian wild ryegrass for reclamation of disturbed lands is available from a wide range of sites throughout Alberta, particularly coal mine waste, although much information is from experimental work. It is regarded as a promising species for revegetation of mined lands in the foothills to reestablish ungulate ranges (144, 209).

Russian wild ryegrass is noted as a slow starter, but has become quite well established on reclaimed coal mine waste in the foothills and in adjacent subalpine areas (354, 269, 267). However in the Crowsnest Pass, Russian wild ryegrass was recorded to be relatively unsuccessful at 1 950 m ASL, apparently due to poor germination and overwintering losses (377). Follow-up studies on coal mine overburden waste there indicated relatively low ground cover provided by all grasses tested, although E. junceus had relatively high biomass production (380). Particularly good establishment is noted where coal mine spoil is topdressed with salvaged soil materials (209). Initial revegetation trials on oil sand tailings in Alberta resulted in mediocre growth relative to other species tested (257). Presently being used in species mix evaluations for revegetation of overburden and disturbed soils in the oil sands area (249). Revegetation trials on coal mine waste in the southern interior of British Columbia resulted in excellent growth of Russian wild ryegrass, except on carbonaceous materials. Good growth was noted on bentonitic clay and gritstone soils, relative to other species (187). Russian wild ryegrass provided very good first year growth on disturbed mineral soils (pipeline development) in Alaska (459), but very poor growth at similar sites in the Northwest Territories (196). In general, this grass proved unsuccessful in establishing growth over one or two years on both organic and mineral soils in these studies (196).

Russian wild ryegrass provides several adaptations useful for revegetation including salt tolerance, alkalinity tolerance, ability to stabilize sand, forage value and commercial availability of seed. It is particularly useful where moisture is deficient.

Festuca arundinacea

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No ___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance		X			
pH Tolerance Acid		4.5			
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence		X			
Palatability		X	X	X	
Browse Tolerance		X			
Moisture Preference	Moist.				
Soil Preference	Medium to fine textured, poorly drained.				

Festuca arundinacea (Schreb.)

SPECIES BIOLOGY

Taxonomy - Tall Fescue (138).

Also *F. elatior* L. (214), *F. elatior* var. *arundinacea* (507).

Origin and Range

Introduced. Tall fescue was introduced into Canada from England in the early 1920's. It is a native of central Europe. It is widely cultivated and is well established especially in the northwestern States (507).

Growth Habit

Tall fescue is a tufted bunchgrass to 100 cm tall (214, 138). It produces an abundance of leafy growth (130, 391). Low-growing turf-type varieties have also been developed.

Nitrogen Fixing - None

Longevity

Long-lived, cool season (712) perennial (138). It may not be winter hardy in northern and western parts of Alberta (391).

Self Propagation

Spreads by seed (138) and rhizomes (400).

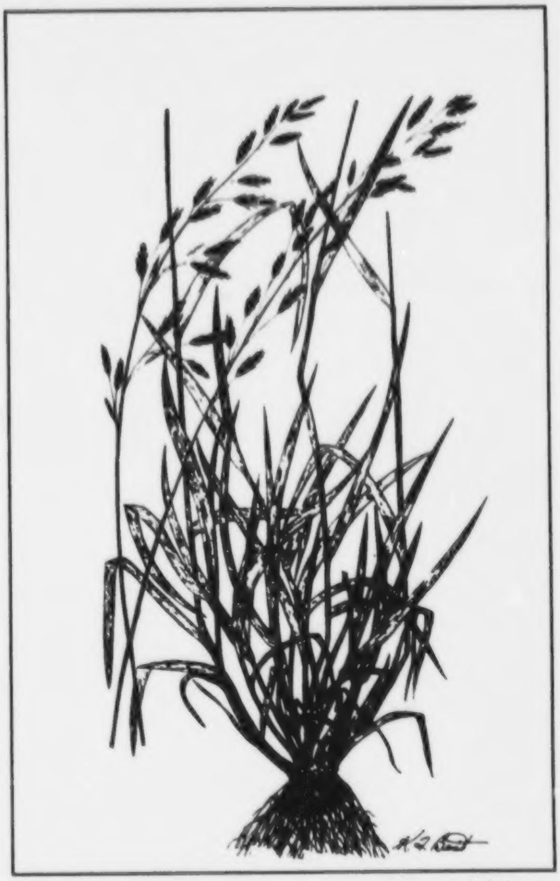
Ecological Setting

Tall fescue is adapted to humid and subhumid climates (67, 183). It has spread from fields to roadsides, yards, fallow fields, ditch banks and waste places. It is well adapted to the moist conditions of eastern Canada and the United States as well as to favorable sites in western North America (433, 138, 507). Requires 40 to 50 cm of precipitation (639). Tall fescue showed decreasing plant cover over three growing seasons when seeded at 2 100 m ASL in southeastern B.C. (119).

TOLERANCES

Soil Preferences

"Kentucky 31" is adapted to a wide range of soil types (138). Tall fescue prefers moist sites and dies out under only limited irrigation (375). Performance has been rated as poor on dry sites and fair on moist to wet sites (422). It does best on heavy soils (183), or moist medium to heavy textured soils (37).



Nutrient Requirements

Tall fescue grows best in moist, well fertilized soils. Adequate fertilization with N, P, K, Ca and Mg is required for long-term maintenance and survival (37).

Soil Reaction

Tall fescue will grow on a wide range of soils from highly acidic to highly alkaline. Although the range of adaptation to pH has been given as 4.5 to 8.0 (423, 444, 712), it probably has the widest soil reaction tolerance range of any commonly grown grass species (138). However, tall fescue had only satisfactory growth on mine spoil of pH 5.4 and had poor growth or failed completely on more acid spoils. Tall fescue has been recommended for planting on alkaline and calcareous spoil (pH >7.3) and acidic spoil (pH 3.6 to 5.5) in Kentucky (346).

Soil Salinity

Tall fescue has a fairly high tolerance of soil salinity. Upper tolerance limits of 8 to 12 mS/cm have been reported (247, 422). It has been recommended as a useful pasture grass on wet or seep lands because of its tolerance to saline soils (391).

Drought

"Alta" apparently remains green during dry summers in western Oregon. "Kentucky 31" and "Arid" turf-type varieties are tolerant of wide temperature extremes (138) and are among the more drought tolerant grasses in the eastern United States (37, 712).

Heavy Metals and Hydrocarbons

"Goens" is tolerant of boron, while "Alta" is only moderately tolerant of boron, at concentrations of 5 ppm in spoil materials (344).

Shade

Presumably prefers open, sunny locations.

Grazing or Mowing

Turf-type tall fescues are tolerant of close mowing (138).

Susceptibility to Disease and Insect Damage

No information available.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Tall fescue is a deep-rooted grass (138), with extensive rhizomes (400). Tall fescue seeded on road backslopes in western Oregon was present only as scattered individuals after the first year (130). Tall fescue increased the amount of organic matter in a mine spoil; available soil moisture increased as well (227). "Kentucky 31" tall fescue is regarded as excellent for erosion control (183). Tall fescue has a fair rate of spread (424). Tall fescue exhibited highest growth rates in spring and fall (375).

Adaptation to Disturbance

Tall fescue is often found in waste places and other disturbed areas in Alberta (312, 78).

Competitive Ability

Tall fescue is said to lack the ability to compete with other grasses on sites where it is poorly adapted (43). Otherwise, its sod-forming habit would indicate good competitive ability.

Commercial Value

Tall fescue is used principally for erosion control, hay and pasture (423). It also can be used to provide wildlife forage (422). Tall fescue produces excellent hay yields when grown with legumes and when properly fertilized and irrigated (391, 375). It also provides excellent waterway protection (391). It has been used extensively for mine reclamation, roadbanks, construction sites and roadside development (37).

Palatability and Nutritive Value

Under certain conditions, forage of tall fescue may be tough and unpalatable. However, it is as palatable as other grass species when properly managed and fertilized (138). Use of Festuca spp. has been reported to be medium for bighorn sheep and elk, high for mule deer and low for moose (144). When grown under irrigation, tall fescue is not as palatable to livestock as other grasses (391). The palatability of "Alta" has been rated as low (427). Palatability of tall fescue may be a problem in mixtures as other species may be preferred. It should be grazed closely for best animal acceptance and feeding value (183).

Seed or Planting Stock Availability

Varieties licensed for use in Canada include "Alta", "Kentucky 31", "Mustang" and "Arid". "Fawn" is available in the US (639). Approximately 565 000 seeds/lb (639).

Methods and Ease of Establishment

Percent germination of seed stored in wooden sheds decreased from 93% in the year of collection to 4.5% after 19 years (211). Typical purity and germination are 96 and 86%, respectively (376). In Kentucky, seeding of tall fescue was most successful in late winter or early spring (444). Ease of establishment has been rated as good (424). Seeding rates of 10 to 20 lbs PLS/ac have been recommended for the eastern US (712); 8 lbs PLS/ac in the spring for the western US (639).

Current Status for Reclamation

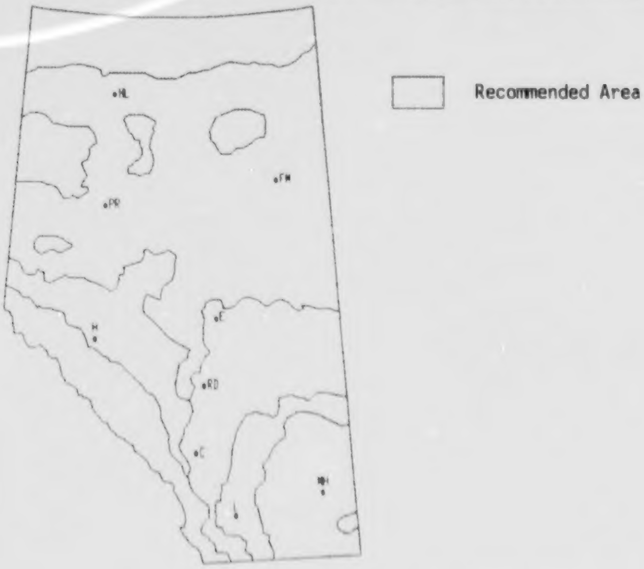
Tall fescue did not prove winter hardy when planted at 2 167 m in Alberta (377), however it had moderate performance on waste rock and overburden at six mines surveyed in the southern interior of B.C. (143). Tall fescue produced a groundcover of 88%, after four growing seasons on uranium tailings near Elliot Lake, Ontario. This species did not yield as well as other species but its sod forming ability was a definite asset (318).

Tall fescue has proved successful for mine reclamation in the western United States, provided it is adequately fertilized (90). It has been used extensively for streambank stabilization (266). "Alta" tall fescue has been recommended for revegetation of critical sites in northwestern Colorado. It was recommended for moist sites at elevations greater than 2 667 m ASL (427). Tall fescue establishes well but is not persistent in the subalpine in Colorado. It is more persistent under foot traffic than Phleum pratense and Agropyron trachycaulum (41). Transplants of tall fescue had poor first year survival on an alpine/subalpine site in Colorado (75). It is widely used in mine spoil reclamation in Kentucky where it was recommended for seeding on spoils with pH values greater than 4.5 (444).

Tall fescue is a long-lived bunchgrass that has a deep root system. It is adapted to a wide range of soil types but does best on heavy soils and requires moist conditions. It is adapted to a wide range of soil reaction classes from moderately acidic to moderately alkaline and is tolerant of soil salinity. Tall fescue can be as palatable as other grasses if proper management and fertilizer techniques are employed.

Festuca ovina

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance				X	
pH Tolerance Acid			X		
pH Tolerance Base				X	
Winter Hardiness	X				
Erosion Control		X			
Persistence		X			
Palatability		X	X	X	
Browse Tolerance		X	X		
Moisture Preference	Dry to moist.				
Soil Preference	Sandy, gravelly to loamy, well drained.				

Festuca ovina L.

SPECIES BIOLOGY

Taxonomy

Sheep Fescue (312); Hard Fescue (138).

Includes F. ovina var. saximontana (Rydb.) Gleason (312), F. ovina var. duriuscula (L.) Koch, or F. longifolia Thuille.

Origin and Range

Regarded as a native by some authors (391). Some varieties introduced from Eurasia (312). Native from Alaska to Newfoundland, south to California, New Mexico and New York (507). This circumboreal species (214) is also found in South America (507). It is found as an escapee throughout the Canadian prairies (78, 312). Includes F. ovina var. duriuscula (F. longifolia Thuill.) or hard fescue (138), which is also introduced (500).

Growth Habit

Sheep fescue is a densely tufted low-growing bunchgrass. It is slender and 15 to 60 cm high (312, 78). Hard fescue is a synthetic perennial turf variety. "Biljart" hard fescue is 15 to 70 cm tall (138). "Parar" hard fescue is a short, fine bunchgrass (232).

Nitrogen Fixing

Does not fix atmospheric nitrogen (331). Evidence of a rhizosheath has been observed in populations of sheep fescue on disturbed sites in Alberta. Such a rhizosheath may have the ability to fix atmospheric nitrogen and contribute to the success of this species in colonizing nutrient poor sites (P. Lulman, pers.comm.).

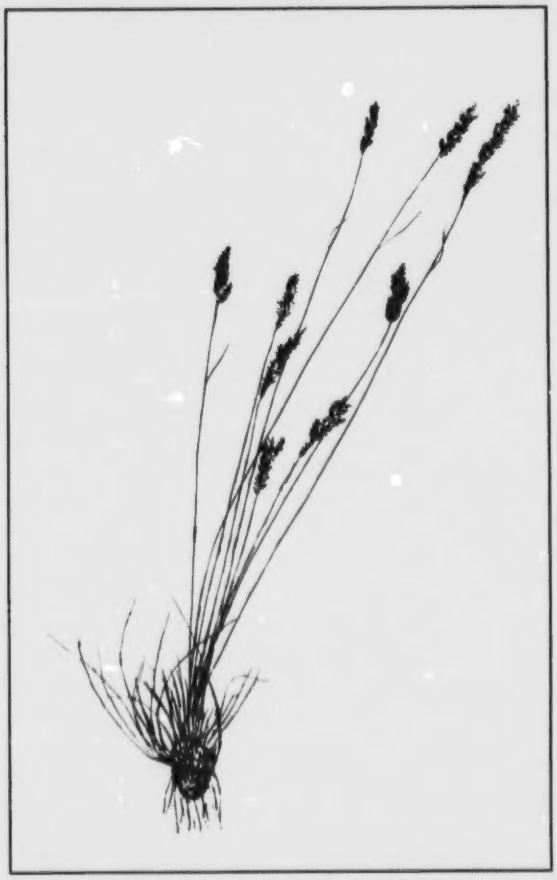
Longevity

Long-lived, cool season (639) perennial. Several plantings of "Durar" hard fescue in Colorado are over 20 years old (131). It has excellent winter hardiness (139).

Self Propagation

Sheep fescue reproduces from seed (312).

Ecological Setting



Sheep fescue is found from gravelly prairies to alpine slopes (507). Plants have been selected at 3 467 m ASL in Montana (465). Sheep fescue is often found on rocky slopes above timberline (185). It has been reported at elevations between 1 667 to 3 267 m ASL on moist to dry sites in Carbon County, Wyoming (18). Requires 25 to 30 cm of precipitation (639).

TOLERANCES

Soil Preferences

Sheep fescue is better adapted than most grasses to sandy, gravelly soils. It is used as a turfgrass on sandy soils in the northern States of the US (183). "Durar" hard fescue is adapted to well drained soils (426). Sheep fescue is adapted to dry to moist habitats. Optimum slope is 9 to 30% and optimum soil depth is 30 to 60 cm. Growth on sandy and loamy soil is good, while on clayey soil it is only fair (446).

Nutrient Requirements

Hard fescue has low fertility requirements (500).

Soil Reaction

Sheep fescue is reported to grow on acid mine wastes in Britain (387).

Soil Salinity

"Durar" hard fescue has poor salt tolerance (424).

Drought

Hard fescue is adapted to fairly dry sites (41). Sheep fescue is drought tolerant but less so than hard fescue (183). Hard fescue is adapted to areas receiving approximately 36 cm or more mean annual precipitation (426).

Heavy Metals and Hydrocarbons

Herbage comprising principally of sheep fescue and sedges showed no toxicity symptoms when grown on soil with concentrations of Pb at 3 680 ppm, Zn at 1 330 ppm and Cu at 48 ppm. However, concentrations of up to 74 ppm Pb, 230 ppm Zn and 31 ppm Cu were found in the herbage (11).

Shade

Hard fescue can tolerate shady areas (427). Sheep fescue is used for turf in shaded areas (391).

Grazing or Mowing

Hard fescue has good tolerance to grazing (339).

Susceptibility to Disease and Insect Damage

Hard fescue has good resistance to disease and insects (339).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

"Durar" hard fescue has a moderate rate of spread (424). Sheep fescue produces excellent growth cover and root production is high (252). The species can generally be considered a good soil stabilizer.

Adaptation to Disturbance

The aggressiveness of hard fescue has been rated as weak. It is slow in becoming established (500). Its status as an "escapee" however, suggests that it may be a fair pioneer.

Competitive Ability

Hard fescue has very good compatibility with other plants (339), but its aggressiveness is poor (500).

Commercial Value

"Durar" hard fescue is used in Alaska for highway cutbank stabilization (298). It is also used for erosion control and soil improvement in the Pacific northwest (183), the intermountain region, the northern and central Rocky Mountains, and adapted sites in the northern Great Plains (426). Sheep fescue is used as turf grass on sandy soils and for erosion control in the northern US. It is also used for stabilization along canals and on road cuts and fills where moisture is adequate (183).

Palatability and Nutritive Value

Hard fescue has tougher leaves than sheep fescue (183), and is therefore sometimes rated as having low palatability (427). Palatability of spring growth is fairly good, however, decreasing to only fair by summer (339). While sheep fescue is apparently palatable and well grazed in spring, it is not widely used for pasture (183); this may be accounted for by its low stature and forage production (252). Utilization of all Fescue spp. is rated as high for mule deer, medium for bighorn sheep and elk, and low for moose (144). Forage value of sheep fescue has been rated as fair for mule deer, game birds and small mammals. Cover value for mule deer is poor, while it is fair for game birds and good for small mammals (446).

Seed or Planting Stock Availability

"Biljart" hard fescue is a variety licensed for use in Canada; other cultivars are not licensed (138). "Covar" is a newly released U.S. variety and "Scaldis" has been on the market in the U.S. for some time. Approximately 680 000 seeds/lb (639).

Methods and Ease of Establishment

Ease of establishment of "Durar" hard fescue has been rated as good (424); seedling vigor has been rated as moderate to weak (41). Ease of transplanting of hard fescue is very good. Germination rate is very good and it is relatively easy to establish by planting (339). Fall/spring seeding at a rate of 10 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

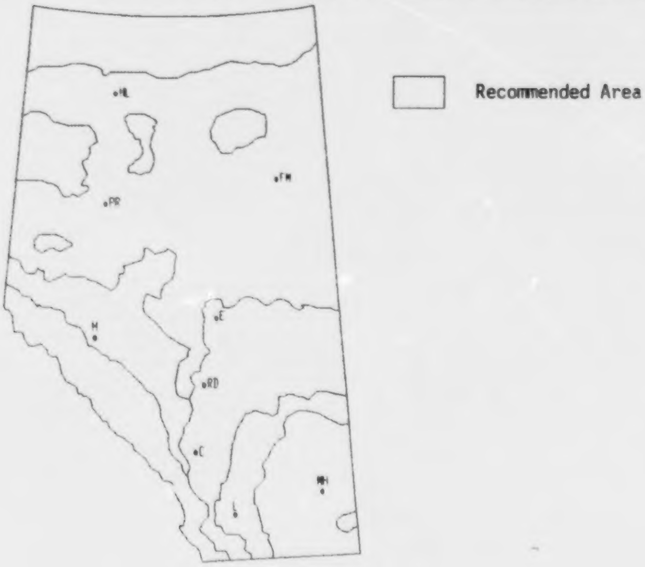
"Durar" hard fescue had excellent second year survival and was among the species which provided adequate third year cover on an alpine site in Alberta (378, 723). Hard fescue showed promise for reclamation use at Grande Cache, Alberta where it provided good cover without excessive top growth and persisted well (268, 269, 271). It provided good cover for four years in the arctic tundra (Mackenzie River Delta) and then declined (644). Sheep fescue produced good first year ground cover (111) and has persisted well for 12 years (644) on a simulated pipeline right-of-way near Norman Wells, N.W.T. (latitude 66° N). Good growth of sheep fescue on tailings sand has been reported in a growth chamber study (209). At Fort McMurray, sheep fescue produced very good fourth year cover on amended tailings sand (643).

Selection of sheep fescue is being carried out in Alaska for possible use in revegetation of dry sites (298). "Durar" hard fescue has also been recommended for revegetation use in Alaska (5) and for critical area planting in areas receiving at least 30 cm precipitation in the southern Rocky Mountains in Colorado (424). Hard fescue has been suggested as a species useful in certain situations in the subalpine in Colorado. This species did suffer considerable winterkill in the first two years when seeded at Climax (3 767 m ASL) in Colorado (41). Subsequent reports however indicate that it was persistent at this site and was one of the best performing species on several subalpine sites in Colorado (236). "Durar" hard fescue has been recommended for revegetation of mountain sites above 1 000 m ASL in California in situations which require a short, uniform and fine textured cover (232).

The advantage of sheep (and hard) fescue is its wide adaptability over a range of habitats from prairies to alpine slopes. It does well on dry to moist sandy or gravelly soils; its nutrient requirements are low and it has excellent winter hardiness. Sheep fescue is tolerant of acid soils and high levels of certain heavy metals. It has potential use for erosion control and revegetation across Alberta.

Festuca rubra

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance		X	X		
pH Tolerance Acid		4-5			
pH Tolerance Base			X		
Winter Hardiness	X	X			
Erosion Control		X			
Persistence		X			
Palatability	X				
Browse Tolerance		X			
Moisture Preference	Moist.				
Soil Preference	Wide textural range.				

Festuca rubra L.

SPECIES BIOLOGY

Taxonomy - Red Fescue

Origin and Range

Red fescue is a widely distributed grass of the northern temperate zone. About one hundred species of fescue occur in temperate and cool climate zones (633). Forms of this species are native to North America, North Africa, Eurasia and Iceland (507), Alaska to Newfoundland, south to southern California, New Mexico, Texas and South Carolina (507). An extremely variable species (214). Variety arenaria (Osbeck) Fries has been reported at Lake Athabasca, northern Alberta. The species is regarded both as a native species in Alberta and as an escapee from cultivation (312).

Growth Habit

Red fescue is a loosely tufted, sod-forming grass with matted rootstocks. Decumbent with short rhizomes (312, 507). Three distinct forms of red fescue are distinguishable by their creeping habits. Creeping red fescue (Festuca rubra var. rubra) spreads by strong underground stems. The chewings fescue type (Festuca rubra var. commutata) is tufted and does not spread. The foliage is finer and the seed culms are shorter than creeping red fescue. The third type is intermediate between chewings and creeping red fescue, and forms short rhizomes (138).

Nitrogen Fixing

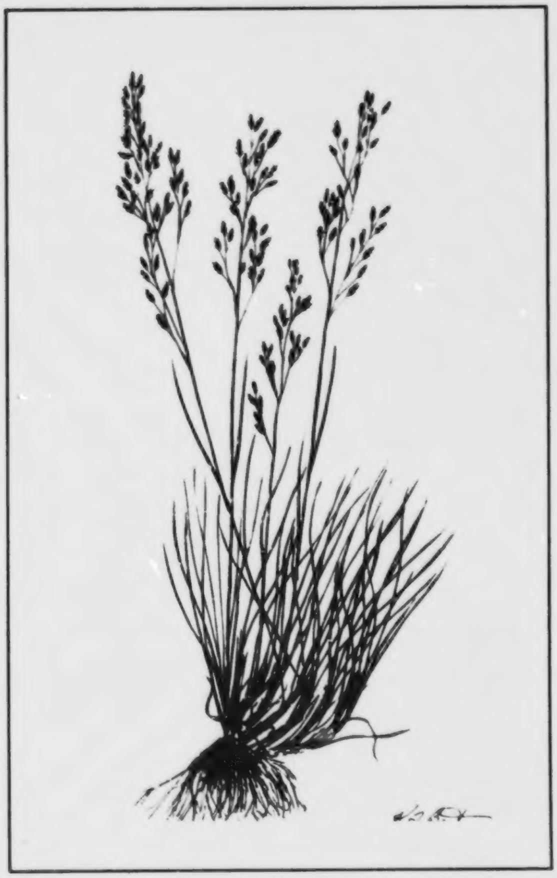
Evidence of a rhizosheath has been observed in populations of red fescue on disturbed sites in Alberta. Such a rhizosheath may have the ability to fix atmospheric nitrogen and contribute to the success of this species in colonizing nutrient-poor sites (P. Lulman, pers.comm.).

Longevity

Cool season (639) perennial (312). Apparently its susceptibility to disease reduces its longevity (435). It is unaffected by frost (137).

Self Propagation

Seed. Some varieties spread by rhizomes (138).



Seed is produced abundantly where there is ample moisture and nutrients (137).

Ecological Setting

Red fescue is found from coastal marshes and sand dunes to montane forests and meadows (507). It is found along shores and in lake meadows in Alberta (312). It is used extensively for forage and lawn turf throughout Canada (138). Red fescue thrives in cool, moist conditions and does best in areas where it receives ample moisture; 45 cm minimum (639). It starts to grow early in the spring, grows slowly in midsummer and then grows vigorously until freeze-up. It is a dominant component of tidelands in Alaska (4). Red fescue is an important introduced ground cover species in boreal and mixed wood forests, the Peace River parkland, on some sites in the central parkland, and in the fescue grassland regions in Alberta (435).

TOLERANCES

Soil Preferences

Red fescue is adapted to a wide range of soil types including Chernozemic and Luvisolic soil zones of the western provinces. It needs less moisture than timothy (Phleum pratense). It is not suitable on drier Chernozemic soils except under cultivation (137).

Nutrient Requirements

Red fescue grows well on both fertile and poor soils. It grows better on poor soils than Kentucky bluegrass (Poa pratensis) or timothy. Nitrogen fertilizers increase the productive period of the stand and increase the seed yield. Good response to additional phosphorus has also been recorded in central Alberta (137).

Soil Reaction

Red fescue is tolerant of soil pH in the range of 4.5 (37). It is also reported to grow on calcareous material (387).

Soil Salinity

"Arctared" red fescue was successfully established on tailings with electrical conductivities of 20 to 24 mS/cm. This was attributed to favorable early season precipitation (163). Elsewhere, red fescue was not affected by soil salinity of 5 mS/cm, but plants appeared to lack vigor at soil salinity levels of 9 mS/cm and 19 mS/cm (404).

Drought

Red fescue is less drought resistant than crested wheatgrass (Agropyron cristatum), and it requires irrigation when grown in drier areas of Alberta (137). It is a component of a seed mix developed for droughty soils in Wisconsin. This mix gave good ground cover on a silty sand subsoil (77).

Heavy Metals and Hydrocarbons

Growth of red fescue was stimulated by the application of residue of Kuwait crude oil. Possible reasons given were release of nutrients from the oil, from oil-killed vegetation, or an hormonal effect (26). Red fescue has been rated as having a medium tolerance to oil (282). Populations of red fescue are tolerant of heavy metals in calcareous lead/zinc wastes in Wales (386). "Boreal" performed well in a grass/legume mix on an ash lagoon west of Edmonton (696).

Shade

Red fescue is tolerant of shade (37). It does well as a bottom grass in pasture mixtures (137).

Grazing or Mowing

The dense turf of red fescue tends to bunchiness if not closely clipped. Regular mowing at a height of 4 to 5 cm will maintain a good turf which will control weeds. Cutting closer than about 4 cm will reduce stand vigor (137). Presumably also tolerates close grazing similarly.

Susceptibility to Disease and Insect Damage

Some varieties show susceptibility to red thread, powdery mildew, rust and leaf spot diseases; others such as "Olds" are not subject to disease in Alberta (138).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Red fescue is a deep rooting species (138). It has an extensive, fibrous root system and a creeping habit. It is regarded as a valuable species for soil-building (137). Produces a stable, crumb-structured soil (633). In four years red fescue developed a thick sod and a ground cover of 95% on pyritic uranium tailings near Elliot Lake, Ontario (318).

Adaptation to Disturbance

The dense turf of red fescue can withstand heavy trampling (137). Presumed to be a moderately good colonizer.

Competitive Ability

Red fescue effectively outcompeted alfalfa and the alfalfa was effectively eliminated by the third growing season (24). It is not as aggressive as the strongly creeping grasses such as bromegrass (Bromus inermis) (137).

Commercial Value

Red fescue is used in mixtures for dryland and irrigated pastures and for erosion control on irrigation ditches and permanent waterways in cultivated fields. It is also used for seeding along seismic lines, pipelines, and highway and railway rights-of-way. It is also used extensively for home lawns, playgrounds, cemeteries, parks and industrial areas over most of Canada (633). Red fescue is grown for seed in the Peace River area and the Olds-Innisfail region of Alberta. It is not a good hay crop as it is too short and is hard to cut (137). Red fescue is regarded as one of the best pasture grasses in the foothills and can provide grazing until the snow is deep (391).

Palatability and Nutritive Value

Red fescue is extremely palatable throughout the growing season. It maintains its green color and above average protein content into autumn (138). Red fescue provides succulent winter pasture without injury to stand. It also provides early spring grazing and, if not severely overgrazed during the summer, it will produce succulent fall pasture (137). Use of Festuca spp. has been rated as medium for bighorn sheep and elk, high for mule deer and low for moose. Seeds of red fescue are favored by meadow voles (111). Palatable to cattle and horses (633).

Seed or Planting Stock Availability

Varieties of red fescue which are licensed for use in Canada are: "Arctared", "Boreal", "Dawson", "Duraturf", "Duralawn", "Highlight", "Jamestown", "Koket", "Pennlawn" and "Reptans" (138). Approximately 615 000 seeds/lb (639).

Methods and Ease of Establishment

Red fescue has aggressive seedling growth and fast sod development (49). Seedling vigor has been rated as fair to good (41). Fall/spring seeding at a rate of 10 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

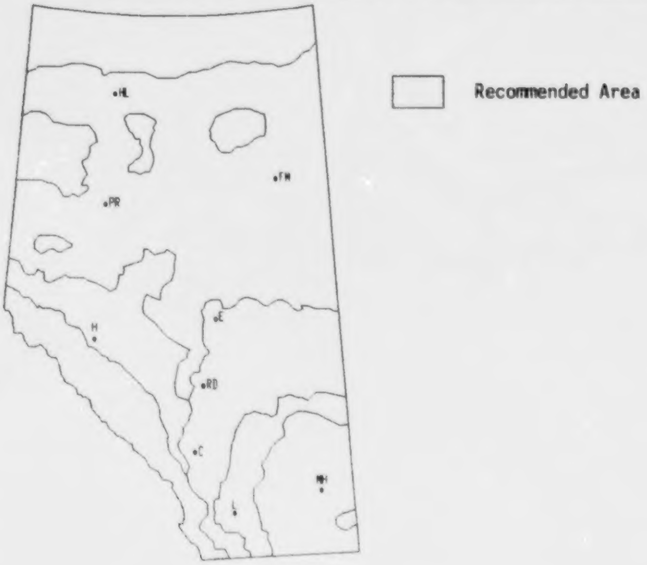
Red fescue is widely used in mine reclamation (633). "Boreal" red fescue consistently performed well after five to six years of testing in subalpine and alpine sites along the eastern slopes region of Alberta (378, 705, 722, 732, 740). The native variety and "Boreal" performed equally well after five years in the alpine at Tent Mountain. "Arctared" and "Erica" chewings fescue also had excellent second and third year survival at Tent Mountain (378, 723). "Arctared" red fescue maintained a cover of 90 to 95% in the arctic tundra (Mackenzie River Delta) after twelve years while "Boreal" died out after four years (644). "Boreal" was the dominant grass after four years along the Norman Wells to Zama pipeline (644). At Fort McMurray "Boreal" produced the best cover after five years of testing. It has persisted in a mix for 17 years on amended tailings sand and overburden with minimal fertilization (641). "Boreal" was the best grass in mixed seedings after five years at Cold Lake (685) and Swan Hills (646). In the Peace River Coal Block, growth of red fescue was good above treeline and excellent below treeline. At seven metal mines in southern B.C., initial performance of red fescue was good on waste rock overburden, and excellent on tailings (143). Red fescue performed well on various disturbed sites above 1 650 m ASL in southeastern B.C. It was also successful on test plots established at 2 200 m ASL (494).

"Boreal", "Arctared" and "Olds" have been recommended for revegetation use in Alaska (5). Research is presently ongoing in Alaska to derive a red fescue superior to "Arctared" for winter hardiness and snowmold resistance for use in grazing, turf and revegetation (298). Red fescue has shown promise on upper subalpine sites in Colorado, particularly sites that have long periods of snow cover (41, 236). Red fescue is used for disturbed land revegetation in the eastern US (37). Red fescue has been recommended as a species suitable for use in sand dune stabilization (482). It has shown promise as a grass that suppresses undesirable weedy growth on replanted forest clearcuts (633).

Red fescue is a variable species adapted to a wide range of soil conditions and climatic regimes. It has a low maintenance requirement. Although it is drought tolerant, it does best on cool, moist sites. It is quite tolerant of saline soils. This species is used extensively for erosion control and as a turf grass because of its low creeping growth habit and its aggressive sod-forming properties. Several varieties have excellent winter hardiness and show promise for revegetation of disturbed sites to the alpine in Alberta.

Hierochloe alpina

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base				X	
Winter Hardiness	X				
Erosion Control		X			
Persistence			X		
Palatability				X	
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Sandy to stony.				

Hierochloe alpina (Sw.) R. & S.

SPECIES BIOLOGY

Taxonomy - Sweetgrass; Vanillagrass (199)

Origin and Range

Native, with circumboreal distribution; extending south from Alaska along the Rocky Mountains (66).

Growth Habit

Sod-forming grass 10 to 40 cm tall (241). The foliage is sparse, mainly basal, and not particularly dense (241).

Nitrogen Fixing - None

Longevity

Perennial (405). Tendency for sod binding to occur in older stands (66).

Self Propagation

Seeds. Seed sets described as generous (66). Nursery observations indicate seed is of good size and germinates freely (66). Spreads very rapidly by rhizomes (241).

Ecological Setting

Alpine meadows and heaths, and rocky slopes to at least 1 800 m (214). Also noted as an early colonizer of dry, sandy, and stony burned areas in the Northwest Territories (209).

TOLERANCES

Soil Preferences

Growth on dry, sandy soils noted (209).

Nutrient Requirements

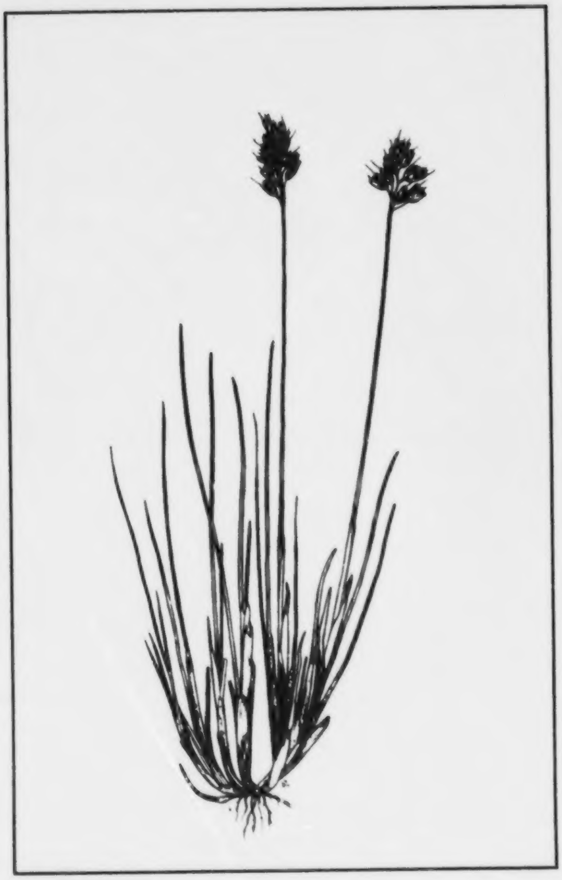
Found on low nutrient sites. Responds to nitrogen fertilization.

Soil Reaction

Observed to favor slightly acidic to neutral soils.

Soil Salinity

Will not tolerate excessively saline sites.



Drought

Will tolerate short periods of drought.

Heavy Metals and Hydrocarbons

No data on tolerances available.

Shade

As an alpine grass, H. alpina is judged to be at least somewhat shade intolerant.

Grazing and Mowing

Hierochloe spp. are not very palatable to native ungulates and horses, and therefore have a moderate chance of surviving even in areas where grazing pressure is quite high (66).

Susceptibility to Disease and Insect Damage

The aroma and bitter taste of Hierochloe spp., attributable to the chemical coumarin, enhances the use of sweetgrasses for bedding material and basketry because it reduces pests in bedding and damage by insects (66). No information regarding disease was located from the literature.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

A related species, H. odorata (the prairie representative of Hierochloe), is regarded as an excellent grass to help control water erosion (9). This capability is attributed to shallow, but numerous, roots (9). Nursery growth of H. alpina is characterized by "fairly tight" sod (66). Soil binding and erosion control capability are therefore thought to be good.

Adaptation to Disturbance

Will invade disturbed sites in adapted areas. Noted to invade burns in the Northwest Territories (209).

Competitive Ability

Heavy sod production promotes competitive advantage.

Commercial Value

A related species, H. odorata, has been used for fine basketry, in ticking (bedding material) and in perfumery (66). Erosion control value as well.

Palatability and Nutritive Value

Field observation indicate that large areas of Hierochloe were pawed and churned up by moose and that the rhizomes were eaten (66). The species appears to be grazed less than most range grasses.

Seed or Planting Stock Availability

Not currently available commercially. Undergoing testing (66).

Methods and Ease of Establishment

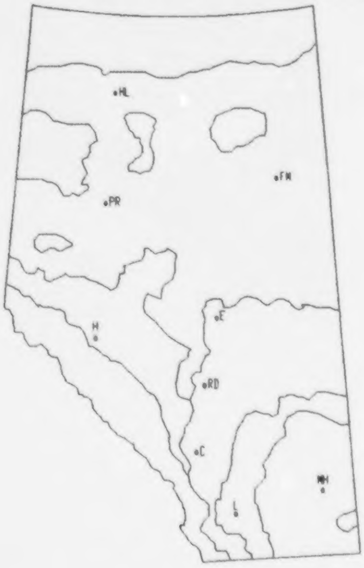
Clones of H. alpina gathered in the field have been successfully transplanted to nurseries; seed obtained from nursery stock has produced good stands on disturbed alpine land (66).

Current Status for Reclamation

This sweetgrass would seem to be suitable for introduction to cultivation (66). Seed of H. alpina, produced on small nursery plots at the University of British Columbia, has given good stands on disturbed alpine lands in the B.C. interior low snowfall zone (66). The bitterness of Hierchloe spp. may make them useful for roadside seedings and in other areas where grass, but not grazing by ungulates, is desired (unpalatable erosion control grasses) (66).

Hordeum jubatum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



☐ Recommended Area

Commercially Available: Yes___ No_X_

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance				X		
Salt Tolerance		X				
pH Tolerance	Acid					X
	Base			X		
Winter Hardiness			X			
Erosion Control			X			
Persistence			X			
Palatability				X	X	
Browse Tolerance				X		
Moisture Preference		Dry to wet.				
Soil Preference		Loamy to clayey.				

Hordeum jubatum L.

SPECIES BIOLOGY

Taxonomy - Foxtail Barley

Origin and Range

Native. Alaska east to Newfoundland. Northern United States and south in the mountains to Mexico (214, 9). Variety caespitosum (Schribn.) Hitchc. (bobtail barley) is common on saline flats and around sloughs on the prairies (312). Hybrids occur with H. breviaristatum and Agropyron pauciflorum (214).

Growth Habit

Erect, tufted bunchgrass, 30 to 100 cm tall, erect or decumbent at base (312).

Nitrogen Fixing - None

Longevity

Perennial (312), annual or biennial (214).

Self Propagation

Foxtail barley is a prolific seed producer; the seeds are readily spread by wind (9).

Ecological Setting

Commonly found in low meadows, fields and in waste areas. It is the dominant species on moist and saline flats throughout the prairies (312, 78). In Alaska, it is found on river banks and sandy soil, and along roads as a weed (214). Commonly found on lowland communities with restricted soil drainage (450, 254).

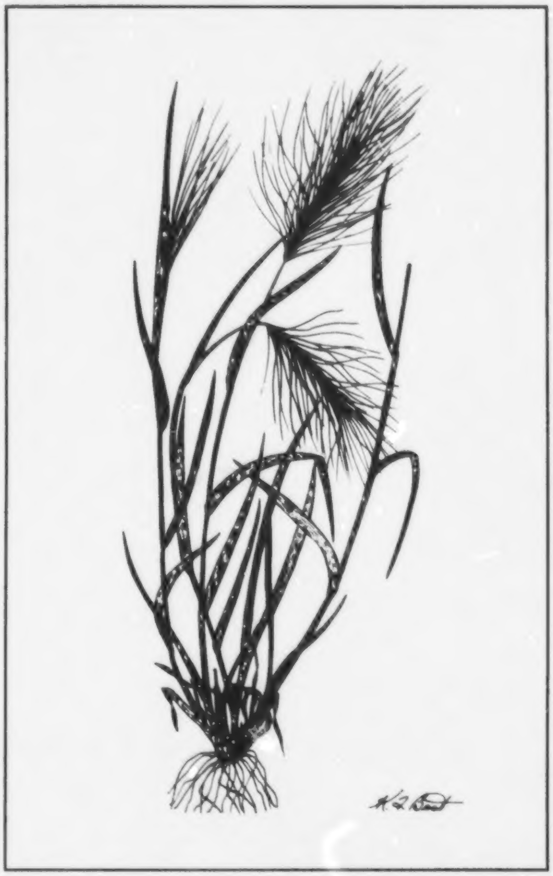
TOLERANCES

Soil Preferences

Foxtail barley is adapted to a wide range of moisture regimes from dry to wet. The optimum soil depth has been reported as 30 to 60 cm and the optimum slope is 0 to 8%. Growth on loamy and clayey soil is reported to be good, while growth on sandy soil is fair (447).

Nutrient Requirements

Nutrient requirements of foxtail barley are moderate. Seedlings established on acid mine tailings had better survival and growth when fertilized (246).



Soil Reaction

Prefers basic soils. Will not tolerate acidic soils (246). Commonly found on somewhat alkaline sites (4).

Soil Salinity

Foxtail barley is commonly found on soils that are slightly saline (4). It was successfully established on saline mine tailings with conductivities in the order of 20 to 24 mS/cm (163). Foxtail barley has been reported as a pioneer on saline mine spoils that are highly sodic in some areas (316). It is an important component of the prairie cordgrass community characteristic of strongly saline soils. The electrical conductivities in those locations range from 17 to 23 mS/cm (469).

Drought

Although this species is generally found on moist sites, it can withstand physiologically droughty conditions.

Heavy Metals and Hydrocarbons

Foxtail barley had limited growth on tailings high in Cu (1 710 ppm) and Zn (178 ppm) and subject to high temperatures reported at 30°C (246).

Shade

Prefers bright sunny sites.

Grazing or Mowing

Invades overgrazed ranges due to the unpalatability of the seeds (78). Expected to be tolerant of mowing as it thrives on roadsides which are mown.

Susceptibility to Disease and Insect Damage

No specific pests or diseases were noted from the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Extensive root systems and aggressive habit make this species good for erosion control and soil building.

Adaptation to Disturbance

Plants can become established on freshly seeded pastures and hayland, and cause the pasture or hay to become unpalatable (9). Foxtail barley is a pioneer on disturbed sites in the Yukon, especially where the soils are basic (246). It has been reported as a pioneer on disturbed sites near Norman Wells, N.W.T. (45, 110). Foxtail barley is also found as a pioneer on mine tailings in B.C. (384). Wild barley has been noted to vigorously invade fertilized pasture, or fertilized ground prepared for planting (455).

Competitive Ability

Very aggressive on adapted sites.

Commercial Value

Regarded as a weed species (312). Value for erosion control.

Palatability and Nutritive Value

Produces low quality hay because of the unpalatable seeds. The long awns often cause mouth, eye or skin irritation to grazing animals (78, 9). Foxtail barley is apparently palatable before flowering (78). Forage value is reported to be good for mule deer and small mammals, and fair for game birds. Cover value is fair for game birds, and good for small mammals (447).

Seed or Planting Stock Availability

Not currently available commercially, but a prolific seed producer in native stands.

Methods and Ease of Establishment

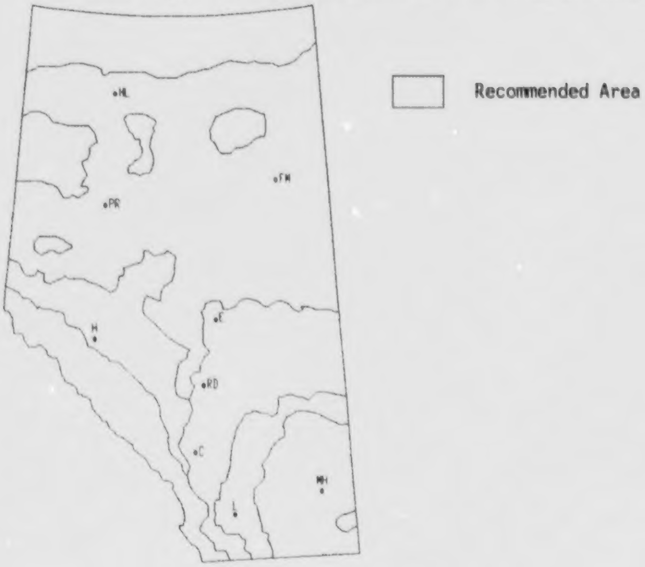
Considered a weed, so seed production may be hindered by the Noxious Weed Act. Seeding is expected to provide the best results. The long awns may clog machinery. Establishment requirements are rated as low (447).

Current Status for Reclamation

Wild barley is found throughout Alberta on a wide range of moisture regimes. It is an aggressive pioneer on disturbed sites. This species is tolerant of saline and sodic soils and certain heavy metals. It has potential for revegetation of saline mine spoils where forage value is of secondary importance. Foxtail barley has been recommended as a species suitable for rehabilitation of wildlife habitat on disturbed lands in Montana and Wyoming (447).

__Koeleria__ __macrantha__

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance				X	
pH Tolerance Acid				X	
Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance			X		
Moisture Preference	Dry to moist				
Soil Preference	Wide range				

Koeleria macrantha (L.) J.A. Schultes f.

SPECIES BIOLOGY

Taxonomy - June Grass

K. cristata (L.) Pers., K. nitida Nutt

Origin and Range

Native. A common species of the prairie throughout Canada and the northern US states. South in the mountains to California. June grass is circumboreal in distribution (312, 78, 214).

Growth Habit

A low tufted bunch grass with a spike-like head 3 to 15 cm long (78). Culms are usually 20 to 50 cm tall (312).

Nitrogen Fixing - None

Longevity - A long-lived perennial.

Self Propagation

June grass flowers early in the summer (78), when it is 2 or 3 years old (467). It propagates itself by seed.

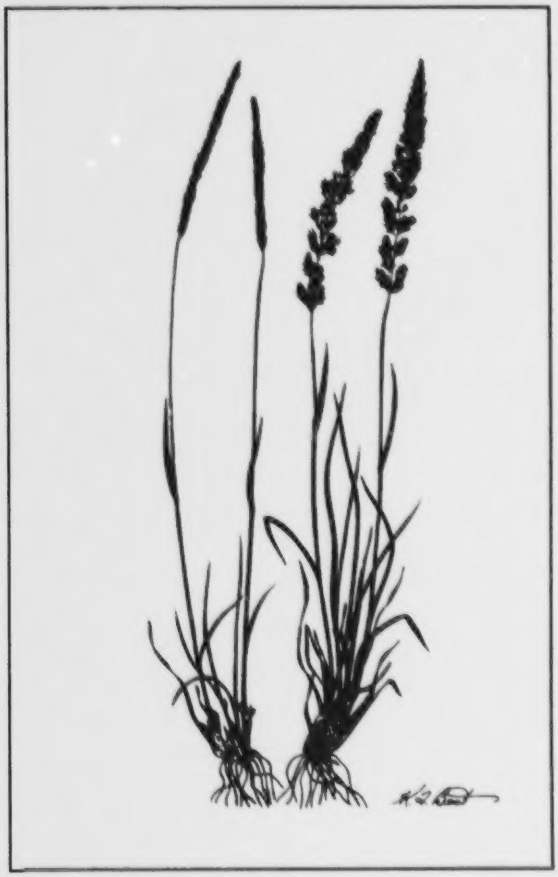
Ecological Setting

It is an important component of the Festuca Association of the aspen parkland and the Agropyron-Stipa Association found in south-eastern Alberta, the Peace River prairie and is found on dry open slopes of the foothills and mountains (455). A very common species of the Canadian prairie particularly in southern areas. Found mainly in dry areas, it has a more slender form in the foothills (78). It is a characteristic species of the grassy subalpine openings found on west- to southeast-facing slopes in Alberta (144). It is a common component of Agropyron-Poa communities of southern B.C. rangelands (114).

TOLERANCES

Soil Preferences

June grass is a characteristic species of the excessively drained high prairie and the sandhills tallgrass prairie (469, 170). June grass is found on Chernozems, and often also on some Brunisols and Regosols, especially in steep terrain.



Nutrient Requirements

Responds to fertilizer applications, particularly N, but will grow on low fertility sites as well.

Soil Reaction

Does best on near neutral soils. May also perform satisfactorily in proximity to alkaline areas (427).

Soil Salinity

Saline tolerance is not known, but is thought to be no more than slight.

Drought

Moderately drought tolerant (427).

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Grows best on open sites but will tolerate some shade.

Grazing or Mowing

June grass increased in cover on sites protected from grazing, especially those sites that had advanced from poor to fair condition. It decreased, however, on sites which reached excellent condition. It is one of the first species to respond to early range protection measures (287). This good recovery rate suggests moderate tolerance to grazing.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The fibrous roots are good for soil building and erosion control.

Adaptation to Disturbance

Has been observed invading disturbed sites.

Competitive Ability

Moderately aggressive in pioneering stands.

Commercial Value

June grass is a valuable forage crop in the prairies (78) and mountains. It also has erosion control value.

Palatability and Nutritive Value

It is highly palatable on Colorado rangelands (427). The species is fairly highly palatable for livestock on southern B.C. rangelands (160). June grass has twice as much crude protein in its leaves as in its culms in the cured state (114). High utilization by bighorn sheep, medium utilization by elk and low utilization by mule deer and moose has been reported (144).

Seed or Planting Stock Availability

No licensed cultivars are currently available, however native seed is occasionally available.

Methods and Ease of Establishment

June grass seed gives good germination after the seeds are moistened with a 0.2% solution of KNO_3 at 20°C for 16 hours, or warmed at 30°C for 8 hours. Light is required for germination (455).

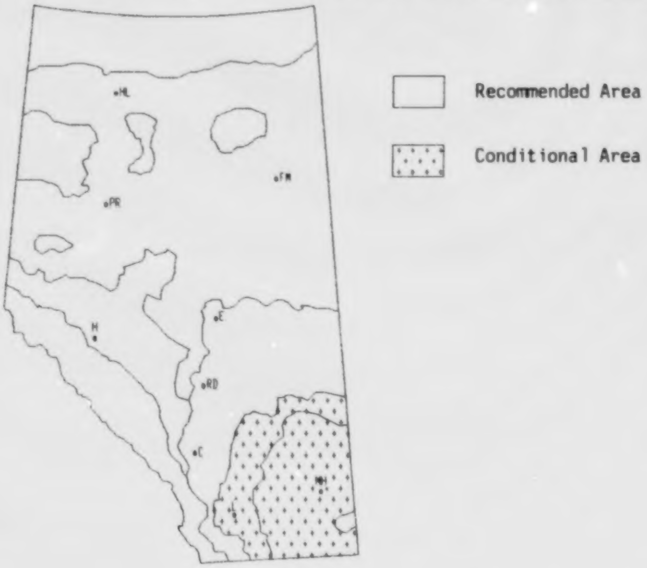
Current Status for Reclamation

June grass has been suggested as a species with potential use for reclamation on coarse textured soils (435). It had been evaluated for reclamation in the foothills near Luscar, Alberta (144). Containerized seedlings, raised from a mixed seed collection from the eastern slopes, had high survival after three years on various alpine and subalpine sites along the Eastern Slopes (366, 723). At Fort McMurray, june grass exhibited high cover and vigor after five years on amended tailings sand soil (705). June grass has been recommended for revegetation of critical sites in northwestern Colorado.

June grass is a widely distributed species found in both the prairies and mountains. It is drought tolerant. Research has indicated that this species has potential for revegetation of disturbed alpine ranges.

Lolium Perenne

SPECIES SUITABILITY MAP AND SUMMARY TABLE



HL
FM
PR
E
H
RD
C
MH
Recommended Area
Conditional Area

Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance					X	
Salt Tolerance				X		
pH Tolerance	Acid		4.5			
	Base				X	
Winter Hardiness			X			
Erosion Control				X		
Persistence					X	
Palatability			X			
Browse Tolerance			X			
Moisture Preference		Moist to wet				
Soil Preference		Wide textural range, moderately to poorly drained				

Lolium perenne L.

SPECIES BIOLOGY

Taxonomy - Ryegrass

Origin and Range

Introduced from Europe; widely cultivated. Newfoundland to Alaska and south to Virginia and California, occasionally further south (199). It is a common pasture grass in western Europe, New Zealand and northeastern United States (47) and Oregon (138).

Growth Habit

Erect, tufted grass with culms 20 to 80 cm tall (199, 47) with a fairly shallow root system (138). It is a cool season grass (712) that tends to die out in hot weather.

Nitrogen Fixing - None

Longevity

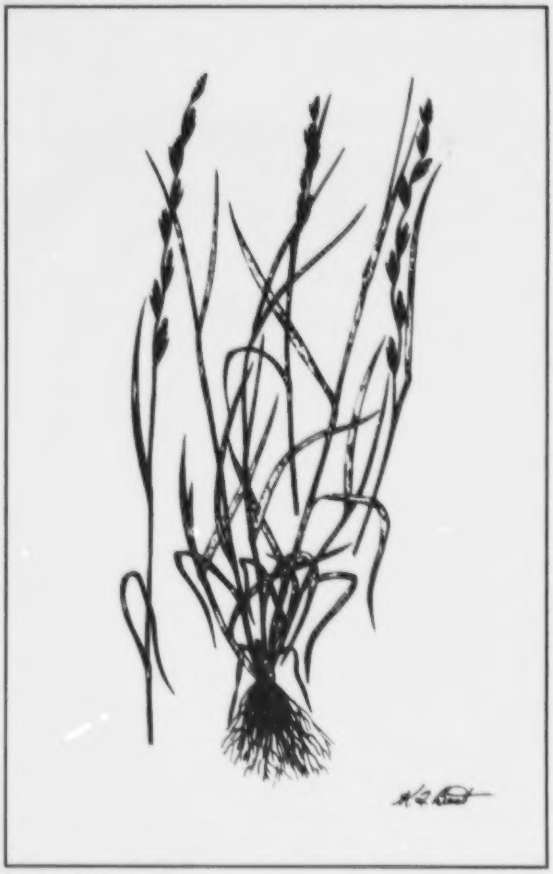
Perennial ryegrass is a rapidly developing (179), short-lived perennial (199), or a winter annual. It generally persists for 3 to 4 years (108). Will not last more than about 3 years on the prairies (D. Walker, pers.comm.). It is completely winter hardy throughout the prairie provinces. "Manhattan" perennial ryegrass is hardier than other strains of the species (209). "Norlea" perennial ryegrass is rated as having excellent winter hardiness for this species (252).

Self Propagation

Propagates by seed or by tillers.

Ecological Setting

Perennial ryegrass is often used in lawn-seed mixtures. It is also found as an escapee in waste places and along streambanks (199). To produce high yields, perennial ryegras requires a fertile soil, a mild climate and about 75 to 125 cm of rainfall annually. The effective environmental zone has been reported to be 40 to more than 152 cm precipitation (500); 30 cm minimum (639). Perennial ryegrass apparently does best in cool, moist regions with mild winters. It is well adapted to the Pacific northwest (183). It apparently will not persist in areas with climatic extremes of cold, heat or drought.



TOLERANCES

Soil Preferences

Perennial ryegrass is adapted to a wide range of soil conditions and soil drainage regimes. It is best suited to soils that are not excessively drained or very poorly drained, provided mean annual precipitation is greater than 45 cm (179). It grows well on heavy soils (183). It will withstand fairly wet soils if there is good surface drainage (500).

Nutrient Requirements - medium to high (500).

Soil Reaction

A lower limit of pH 4.5 has been suggested for the eastern US (712).

Soil Salinity

Perennial ryegrass survived on tailings material with an electrical conductivity of 9 to 15 mS/cm (326).

Perennial ryegrass has moderate salt tolerance (424). Survived on shale with an EC of about 10 mS/cm (344).

Drought

Lolium perenne is not particularly drought tolerant (500).

Heavy Metals and Hydrocarbons

"Wimmera" annual rye grass (L. rigidum x L. multiflorum) has a tolerance of boron in concentration of 5 ppm on shale. Perennial ryegrass had good growth on limed acid tailings with a high gypsum content (20 to 25% Fe) (326).

Shade

It is expected that perennial ryegrass would tolerate at least partial shade.

Grazing or Mowing

"Pennfine" perennial ryegrass is more easily mowed than "Norlea" or "Manhattan" and there is little foliage shedding following mowing with a reel mower (138). Perennial ryegrass tolerates heavy grazing (104).

Susceptibility to Disease and Insect Damage

"Pennfine" perennial ryegrass was developed for snow mold tolerance, among other selection criteria. "Norlea" perennial ryegrass is susceptible to leaf rust (138).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Perennial ryegrass has a fibrous root system (106). "Manhattan" produces abundant tillers under favorable conditions with moderate spreading ability. Decumbent stems may root at the nodes. "Manhattan" produces a moderately dense turf (138). The rate of spread is considered fair (424). It has medium sod-forming characteristics (500). The species can be considered at least a moderately good soil stabilizer.

Adaptation to Disturbance

Perennial ryegrass has been reported as a pioneer on alkaline (pH 9.0) asbestos tailings which were also high in Ni and Cr. Most volunteers were observed on pockets of soil or overburden incorporated into the tailings (310).

Competitive Ability

"Pennfine" perennial ryegrass is not as competitive in mixtures as "Manhattan", but it is more competitive than "Norlea" (138). When seeded with long-lived grasses and legumes, the perennial ryegrass content should be kept below 5% (D. Walker, pers.comm.). More than this will reduce the amount of longer-lived plants through competition (197).

Commercial Value

Perennial ryegrass is used in short-term pasture and hay land, and in lawn-grass mixtures (47). It is generally too short for hay production. In pastures it is often sown with white and red clover. In eastern Canada and throughout southern B.C., it is an important pasture species. It is also used for erosion control (138). Common ryegrass (Lolium spp.) is used to provide a quick ground cover for temporary stabilization of earth structures such as dams, for erosion control on cropland subject to overflow, for winter cover cropping and with clovers as a green manure (179).

Palatability and Nutritive Value

Perennial ryegrass is nutritious and palatable (183).

Seed or Planting Stock Availability

Varieties licensed for use in Canada include "Manhattan", "Norlea" and "Pennfine" (138). Certified seed of "Norlea" perennial ryegrass is available in quantity in Canada. Seed of "Manhattan" and "Pennfine" perennial ryegrass is also available from Canadian seed distributors (138). Seed sources include hybrids of Lolium perenne and L. multiflorum (Italian ryegrass, an annual) which behave as short-lived perennials. Approximately 227 000 seeds/lb (639).

Methods and Ease of Establishment

The typical purity/germination is 98/90% (132). Germination rates of perennial ryegrass on acid (pH 3.3) mine spoil were reduced by soaking the seeds in various concentrations of ammonium nitrate and triple superphosphate fertilizers. This experiment was designed to simulate hydroseeding conditions. Germination was best on unfertilized loamy sand of pH 5.8 (273). Perennial ryegrass is commonly used in lawn-seed mixtures because it germinates rapidly and forms a green turf quickly. It is slightly slower than common ryegrass (Lolium spp. including L. multiflorum) in becoming established, but when fully developed it equals it in production, and is more persistent (179). Perennial ryegrass has been rated as having excellent ease of establishment (424). It is a vigorous and rapidly establishing grass (256). Fall seeding at a rate of 25 to 35 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

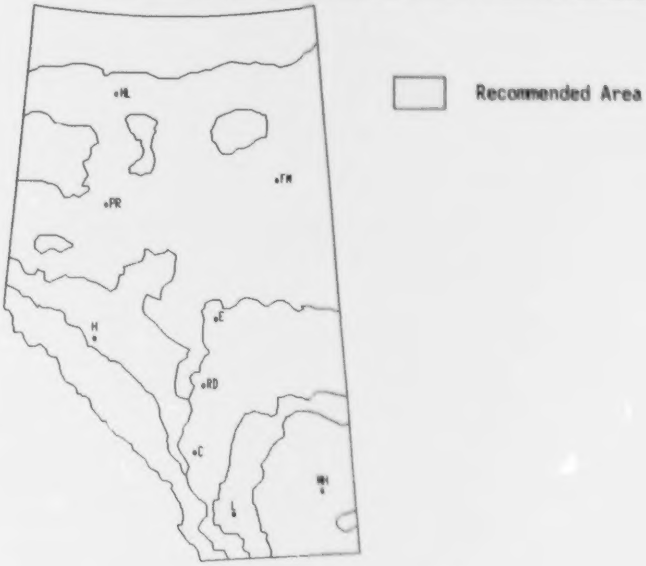
Preliminary results indicate good growth in the subalpine at Grande Cache, Alberta (268). Perennial ryegrass has been used for revegetation of land disturbed by coal mining in southeastern B.C. (119). It has shown promise at sites above 1 650 m in southeastern B.C. but tended to decline at the lower elevations (494). A preliminary survey of five mine sites in southern B.C. indicated that perennial ryegrass has poor performance on waste rock and overburden and was absent on tailings. Most of these sites did not have maintenance fertilization (143). It failed as a companion crop on subalpine test sites at Adanac and Cadomin (705). Perennial ryegrass has also been reported to be suitable for use in the Mackenzie and Yukon River Valleys as a quick nurse crop (398).

In the U.S. perennial ryegrass has been recommended as a species suitable for including in seed mixes designed for quick cover (temporary) to control erosion (346). Perennial ryegrass seeded on road backslopes in western Oregon gave excellent cover for the first year but declined gradually thereafter (130). It has been recommended as a good shortlived filler for use in the subalpine in Colorado (193). It has also been used as part of a seed mix to form a dense ground cover in northern Minnesota and Pennsylvania (123).

Perennial ryegrass is a readily established and vigourous sod-forming grass. It is a cool season grass that tends to die out in hot, dry weather. Winter hardy varieties are available and some may persist for up to three years in favorable conditions. Perennial ryegrass can tolerate soil salinity. It is best suited to moist soils but can withstand wet soils if surface drainage is adequate. This grass has potential use as a companion crop and can provide a quick vegetative cover to prevent surface erosion on moist sites.

Muhlenbergia asperifolia

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance		X			
pH Tolerance Acid					
Base		X			
Winter Hardiness			X		
Erosion Control		X			
Persistence		X			
Palatability			X	X	
Browse Tolerance		X			
Moisture Preference	Moist to dry.				
Soil Preference	Sandy.				

Muhlenbergia asperifolia (Nees & Mey.) Parodi

SPECIES BIOLOGY

Taxonomy - Scratch Grass

Origin and Range

Native (405). Found from British Columbia to California and Mexico, east to Idaho and Montana and to Texas and the Mississippi valley (348). Not common on the Canadian prairies (9).

Growth Habit

Erect and wiry grass of small to medium size. Mostly rhizomatous (312) root system. Grows in dense stands (9). Culms branching at the base and spreading. Slender, and 10 to 40 cm tall (312).

Nitrogen Fixing - None

Longevity - Perennial (withering) grass (405).

Self Propagation

Propagation is both by seeds, and by vegetative spreading from rhizomatous rootstocks (312).

Ecological Setting

Scratch grass is found on the moist prairie, and in meadows of southeastern Alberta (312, 506). In North Dakota, scratch grass occurs on moderately saline surface and strongly saline subsurface soils, in association with foxtail (Hordeum jubatum), slender wheatgrass (Agropyron trachycaulum) and other grasses of the prairie cordgrass (Spartina pectinata) community (469).

TOLERANCES

Soil Preferences

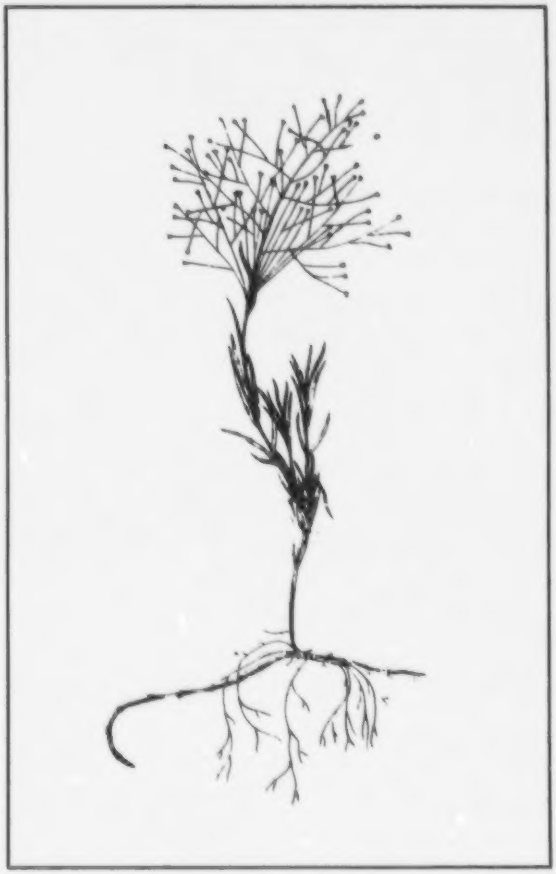
Grows in sandy soil (312) which is usually moist to dry (199).

Nutrient Requirements

Responds to nitrogen fertilization but will grow on sites with moderately low nutrient status.

Soil Reaction

Often associated with alkaline soils (199), and is therefore considered moderately tolerant of high pH.



Soil Salinity

Frequently associated with saline soils (312).

Drought

Generally found on moist sites with good drainage.

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Presumably shade intolerant, based on range and ecological setting.

Grazing or Mowing

Muhly grasses are considered to be "increaser" range plants, increasing in number as more desirable plants are grazed out. Tolerance to mowing is not known.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Extensive root and rhizome systems make this species good for soil building and erosion control, particularly on saline sites.

Adaptation to Disturbance

Rated as an "increaser" on rangeland. Invades disturbed saline sites.

Competitive Ability

A relatively aggressive, rhizomatous species.

Commercial Value

Major value is for erosion control.

Palatability and Nutritive Value

In general, muhly grasses are rated as poor to moderately good forage plants (9). Overall, palatability is inferior to many range grasses.

Seed or Planting Stock Availability

Not known to be available commercially.

Methods and Ease of Establishment

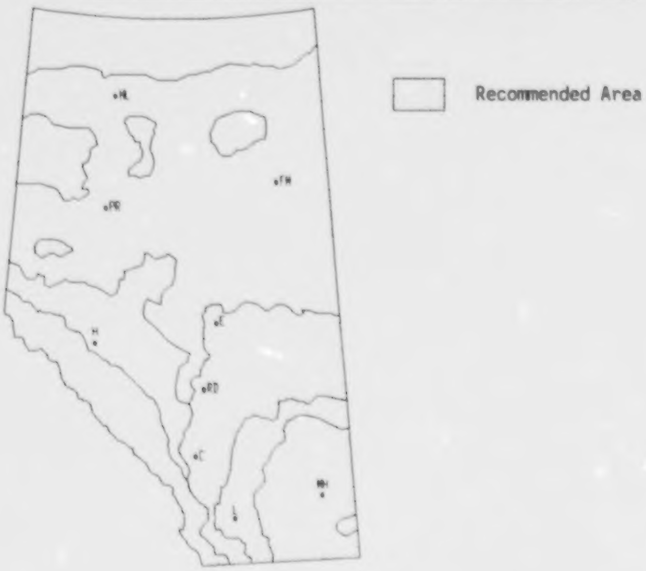
Seeding is thought to be the best establishment method although no reports on establishment were reviewed.

Current Status for Reclamation

No apparent use has been made of scratch grass for revegetation of disturbed lands to date. Distribution favors potential use in southeastern and east central Alberta. Tolerance for saline soils may be useful for revegetation of soils affected by brine spills or sodic soils. Adaptability to sandy and saline soils warrants revegetation research on tailings sand slopes in the Alberta oil sands area, although climatic conditions may present constraints to growth.

Oryzopsis hymenoides

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance		X	X			
Salt Tolerance				X		
pH Tolerance	Acid				X	
	Base			X		
Winter Hardiness			X			
Erosion Control			X	X		
Persistence				X		
Palatability			X	X		
Browse Tolerance			X			
Moisture Preference		Dry.				
Soil Preference		Rocky to sandy, tolerates wide range well drained.				

Oryzopsis hymenoides (R. and S.) Ricker

SPECIES BIOLOGY

Taxonomy - Indian Rice Grass

Origin and Range

Native, widely distributed throughout the western United States (322), from North Dakota to Washington, and south to California and Texas (183).

Growth Habit

Indian rice grass is a tufted, stout grass 30 to 70 cm tall (78, 312). It is a bunchgrass with each leaf growing from the base of the plant (322). Variously described as warm season (322) and cold/cool season grass (183, 639). There is a considerable ecotypic variation within the species (426).

Nitrogen Fixing - None

Longevity

Long-lived perennial (322). Persistence is good (339).

Self Propagation

Seed production is excellent, and natural spreading ability is moderate (339).

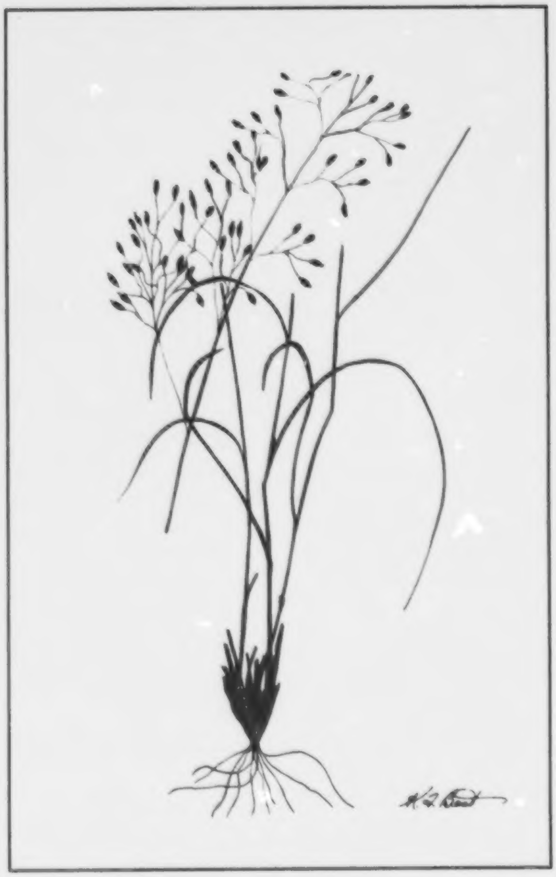
Ecological Setting

Indian rice grass is commonly found on rocky slopes, dry banks and in sandhills in the southwestern prairies (78). It is also a high elevation species in Alberta (378). In the western United States it is found at elevations between 600 to 3 000 m. It is most common in the low semi-arid rangeland to the higher elevation juniper-pinyon zones. Indian rice grass is found on ridgetops on south or west-facing dry slopes at higher elevations (322). Requires 22 cm of precipitation (639).

TOLERANCES

Soil Preferences

Indian rice grass is found on a range of soils from shallow to deep; it is adapted to dry sandy soils (322, 183). It is not adapted to poorly drained soils (322).



Nutrient Requirements

Relatively low nutrient requirements. Appears to respond to modest additions of nitrogen. Annual fertilization rates of 90 kg/ha-N have been recommended as a starting point where no soil test information is available (322).

Soil Reaction

Evidence indicates a probable preference for at least mildly alkaline sites.

Soil Salinity

Indian rice grass is at least somewhat tolerant of soil salinity (285) and it has been used for range improvement in the salt-desert regions of Colorado (428). Indian rice grass seeded on sodic mine spoils near Edmonton did not survive. However, mortality may have been due to flooding (304).

Drought

Indian rice grass is adapted to dry sandy soils. It is one of the most drought tolerant native grasses in the United States (322).

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Observed to be moderately shade tolerant.

Grazing or Mowing

Indications are that the species has excellent tolerance to grazing (339).

Susceptibility to Disease and Insect Damage

"Paloma" indian rice grass tested in Arizona, Colorado and New Mexico did not exhibit any problems with insects or disease (322). Good resistance reported (339).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Fibrous root systems and the ability to survive on extreme sites make this grass a good soil builder. Also noted to have moderate soil stabilizing abilities (339).

Adaptation to Disturbance

Indian rice grass often invades disturbed areas, particularly on sandy sites (455, 322).

Competitive Ability

Good on adapted sites. Compatibility is rated as excellent (420).

Commercial Value

Indian rice grass is mostly used for rangeland restoration (428).

Palatability and Nutritive Value

Indian rice grass is nutritious (183) and palatable to all types of livestock (322). The seeds are eaten by birds (including mourning doves and pheasants) and small rodents (322). It is an important range forage grass in the semi-arid areas of the United States where it is frequently used as a source of winter feed (322). It is reported to be browsed by Rocky Mountain mule deer (245). It has been noted as desirable forage for sheep and deer (425). The forage covers very well (322). Palatability is good in spring, but drops to only fair by late summer (339).

Seed or Planting Stock Availability

Native seed is only available in limited quantities (322) and is very expensive (132). There are many varieties including "Nezpar" and "Paloma" (430). Approximately 141 000 seeds/lb (639).

Methods and Ease of Establishment

Seedheads comprise an open panicle and seeds are readily shed (322, 331). Seed stored for longer than a year after harvest has a much higher rate of germination than freshly collected seed (332). Seed dormancy can be broken by first soaking in concentrated sulphuric acid for 30 minutes, then storing at 5°C for 4 weeks. Germinate the seeds at 15°C in the dark. The seeds can be wetted with a 100 ppm solution of gibberellic acid to promote germination (455). Indian rice grass has excellent seedling vigour and is readily established (426). Best results are obtained by sowing seed in the fall through to mid-winter at 20 to 45 mm depth. Fall seeding at a rate of 6 to 8 lbs PLS/ac has been recommended (639). Deeper placement of seed is recommended on light textured soils. It has been established at other times of the year under certain favorable conditions. Seedlings are susceptible to damping off in wet soil (322).

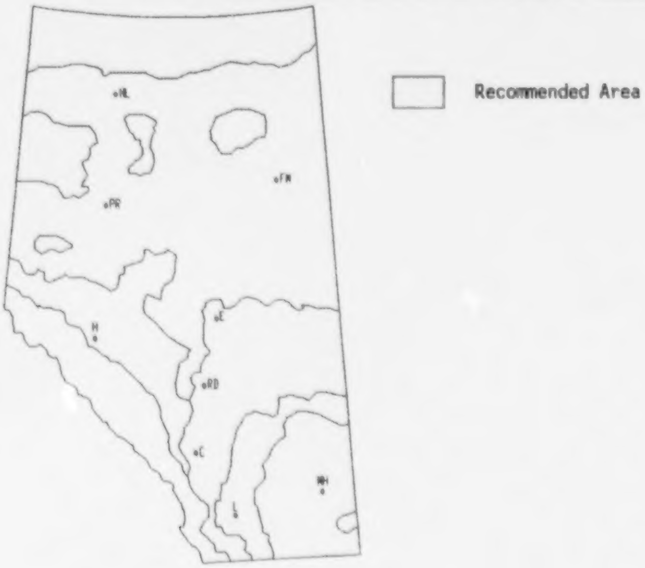
Current Status for Reclamation

Indian rice grass has been used successfully for stabilizing roadcuts and disturbed areas in Utah. It is particularly suited for use in the juniper-pinyon and big sagebrush vegetation zones (336). "Nezpar" indian rice grass is used for range improvement in the intermountain area of the west. "Paloma" indian rice grass is used for range seeding and soil stabilization in Arizona, Colorado and New Mexico (322). Indian rice grass is suited for planting in very dry areas (232). It has been used for revegetation of mine spoils in Arizona (173).

This species is very variable and is found on a range of soil types. It is adapted to dry sandy or rocky soils and is very tolerant of drought. It is relatively resistant to disease and is easily established. The species is used widely in the western U.S. for erosion control and range rehabilitation in dry areas.

Phalaris arundinacea

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance		X	X	X	
pH Acid		5.0	X		
Tolerance Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence	X				
Palatability			X	X	
Browse Tolerance		X			
Moisture Preference	Moist to wet, highly tolerant of flooding.				
Soil Preference	Medium to fine textured, moderately to poorly drained.				

Phalaris arundinacea L.

SPECIES BIOLOGY

Taxonomy - Reed Canary Grass; Reed Canarygrass

Origin and Range

Native. Found throughout the prairies on favorable sites (78). Reed canary grass is circumboreal in distribution (480). It occurs throughout the northern prairie states, Alaska, British Columbia east to Newfoundland (214).

Growth Habit

It is a tall, coarse, cool season grass (258), 0.6 to 1.5 m tall (312). Reported heights for "Castor" are 103 cm, for "Frontier" 89 cm and for "Suba" 89 cm (362). Heights of up to 2.0 m have been reported (5). Reed canary grass grows in dense clumps but will spread by coarse, creeping root stocks to form a close sod when properly managed (171).

Nitrogen Fixing - None

Longevity

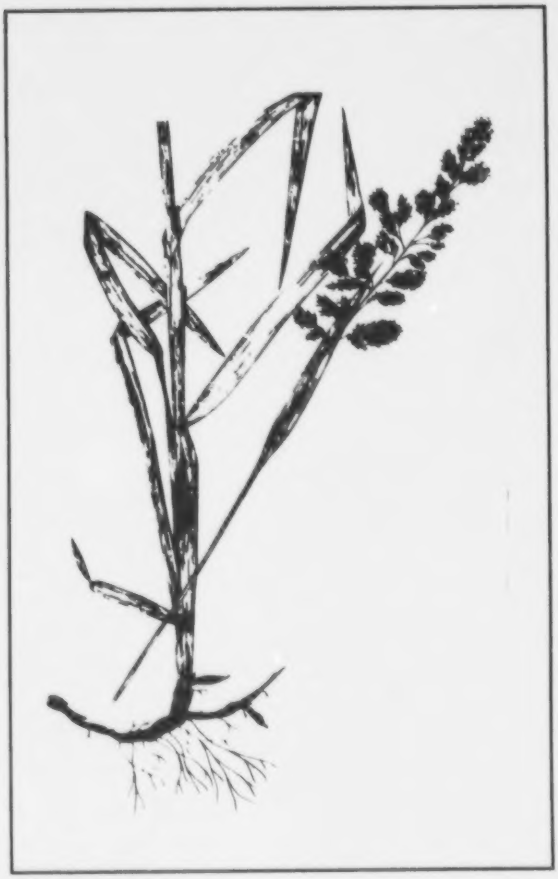
Reed canary grass is a long-lived, cool season (639) perennial (480, 171, 5). "Frontier" has been reported to be moderately winter hardy in Alaska (5). "Castor", "Frontier" and "Suba" have been noted as having excellent hardiness (139).

Self Propagation

Reed canary grass is a sod-forming grass that spreads by rhizomes or creeping rootstocks (480, 331). It has moderate seed production (5).

Ecological Setting

Reed canary grass is commonly found in wet places but not usually in permanent standing water (480). It is well adapted to the northern United States and Canada where there is adequate moisture and the climate is cool (171). Requires 40 cm of precipitation (639). It has been reported between 1 200 and 3 000 m ASL elevation in Carbon County, Wyoming (18). It performed well on several montane and subalpine sites (3 200 and 3 100 m ASL) in southeastern Idaho, northeastern Utah and western Wyoming (209). It does well on upland soil that has adequate moisture for spring and early summer growth (171). It is found growing wild along river banks and sloughs and on land with high water tables (171).



TOLERANCES

Soil Preferences

"Frontier" reed canary grass is reported to be adapted to a wide range of soil groups and textures, and is adapted to moist to wet soils (477, 190). It is highly tolerant of wetness and flooding (5). "Frontier" reed canary grass did poorly on organic soil but better on mineral soil in the N.W.T. (195). Reed canary grass can tolerate flooding for long periods (up to seven weeks) (171). Growth is good on loam soil and clay soil but fair on sandy soil (447). It can be grown on upland soils where adequate precipitation or irrigation is available (426). It grows well on sandy loam muck and peat and also on heavy clay soils (171). The optimum slope for reed canary grass is reported to be 0 to 8% and the optimum soil depth as >63 cm.

Nutrient Requirements

Fertilizer (nutrient) requirements have been variously reported as moderate (100) and low to medium (190, 466).

Soil Reaction

"Frontier" reed canary grass has very good acid tolerance (5). It has been recommended as part of a seed mix for vegetation of spoils with pH of at least 5.0 in Pennsylvania (123). Also considered moderately alkaline tolerant (426).

Soil Salinity

Reed canary grass is moderately saline tolerant (426). It can grow in soils with an electrical conductivity of 5 to 10 mS/cm (468). It should not be grown on strongly saline soils (171), however.

Drought

"Frontier" reed canary grass has good drought resistance (5). It can at least endure short summer drought (500).

Heavy Metals and Hydrocarbons

Reed canary grass is reported to have a good tolerance to oil (5, 113). Other tolerances are not known.

Shade - Favors open sunny sites.

Grazing or Mowing

Reed canary grass has a rapid recovery rate after cutting (5). Cut and uncut plots of reed canary grass showed no difference in groundcover (318). Continuous close grazing results in a mass of roots in the top layers of soil (171).

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Reed canary grass is a sod-forming grass (5) with a medium rate of growth (179). When planted on uranium tailings near Elliot Lake, Ontario it produced complete groundcover rapidly. This provided an effective means of protection against wind erosion. It was, however, rated as a poor sod-forming grass at this site (318). In general, reed canary grass provides low and moderate, long-lasting cover, but total cover is high due to litter production (5, 485).

Adaptation to Disturbance

Reed canary grass was found to spread aggressively onto bare areas of uranium tailings at Elliot Lake, Ontario.

Competitive Ability

It has been rated as a poor companion crop since it will rapidly outcompete other species unless cut (318).

Commercial Value

Reed canary grass is used for mine reclamation on moist or wet sites, or on areas receiving additional moisture. It is used for forage and for erosion control on wet areas (426). It has potential use as a green manure crop because of its good growth rate and herbage yield (318). "Ioreed" was developed for usage by the Soil Conservation Service in Iowa as a rapid-developing, vigourous-sodding, productive perennial.

Palatability and Nutritive Value

Palatability has been rated as low although it has high potential forage yield (5). A new variety "Venture" has improved palatability through reduction in undesirable alkaloids, as has "Palaton". Herbage yields of "Venture", "Frontier", "Castor" and "Suba" have been rated as good to very good (141). Forage value has been rated as good for game birds but only fair for mule deer and small mammals (147). Feeding value and palatability deteriorate rapidly after heading. Crude protein in pasture ranged from 20% to 27% (171). Cut at the proper time (as the heads appear) reed canary grass makes a nutritious and palatable hay (191). Seeds are favored by meadow voles but not by red-backed voles or chestnut-cheeked voles (111). It provides good cover value for mule deer, game birds and small mammals.

Seed or Planting Stock Availability

There are several licensed cultivars available from seed dealers in Canada. These include "Castor", "Frontier", "Vantage" and "Venture" (139, 500). Approximately 533 000 seeds/lb (639).

Methods and Ease of Establishment

Plants produce seed in the second year. Seeds mature from the top of the head downward and the seed starts to shatter about two weeks after flowering (171). Seed of this species does not store well; germination rate declines after about 16 to 18 months in storage. It is recommended that only newly tested seed should be used (426). The species is often difficult to establish from seed (41) though it has been characterized as a quick sprouter. Sow 1.2 to 2.5 cm deep (171). Fall/spring seeding at a rate of 5 to 10 lbs PLS/ac has been recommended (639). Seedling vigour is regarded as weak (323). Transplanting may have some potential (41). Typical purity/germination is 95/90% (132). Stands of reed canary grass may be regerminated by shallow ploughing, allowing it to re-establish by volunteering (171).

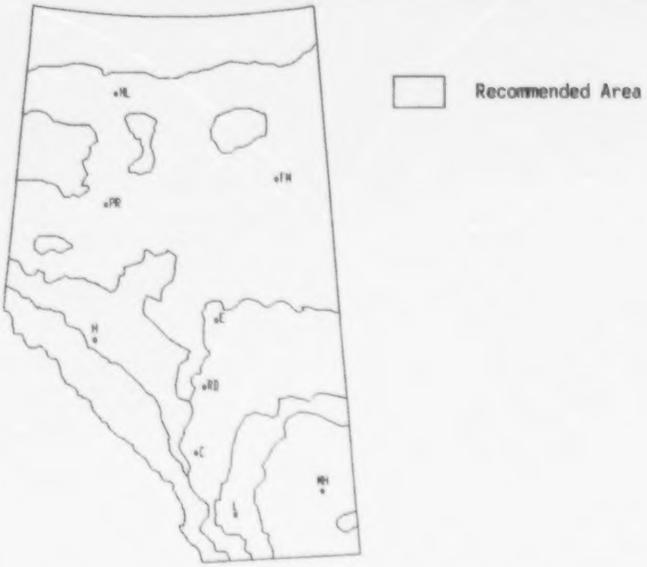
Current Status for Reclamation

"Frontier" reed canary grass has persisted for 12 years on a moist test site in the Upper Mackenzie region of the boreal forest (latitude 66°N) (644). "Vantage" performed well along the Norman Wells to Zama pipeline where, after 4 years, it was restricted to moist to wet areas (644). "Frontier" reed canary grass planted in the arctic tundra, at Inuvik and Tuktoyaktuk, provided excellent first year cover but winter-killed and died out the first winter (195). It has been recommended for pit and quarry rehabilitation in northern and southern Ontario (190). It was able to sustain good growth on saline mine tailings on a climatically severe site in the Yellowknife area (163). Reed canary grass did best on moist sites in the subalpine at several locations in northcentral and central Colorado (236).

Reed canary grass is tolerant of drought, can tolerate flooding and waterlogged soils and is moderately tolerant of saline soils. It spreads aggressively onto bare disturbed areas and is sometimes responsible for choking drainage ditches.

Phleum alpinum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance			X		
pH Tolerance Acid			X		
Base			X		
Winter Hardiness	X				
Erosion Control			X	X	
Persistence			X		
Palatability		X			
Browse Tolerance		X	X		
Moisture Preference	Moist.				
Soil Preference	Sandy loam to silty clay loam, moderately well to imperfectly drained.				

Phleum alpinum L.

SPECIES BIOLOGY

Taxonomy - Alpine Timothy

Origin and Range

Native grass, circumpolar distribution; in North America from Alaska to Newfoundland and along the Rocky Mountains and most mountain subalpine areas of the western United States to South America (214, 199); in Alberta, common in the Cypress Hills (312).

Growth Habit

A shallow rooted grass with short creeping rootstalks (506) and with culms solitary or in small tufts 20 to 50 cm tall (312). It has fairly dense basal leafage (506).

Nitrogen Fixing - None

Longevity - Perennial bunch grass (405).

Self Propagation

Self propagation is primarily by seed.

Ecological Setting

Mountain slopes and alpine meadows, to about 1 700 m (214); also forest borders and open slopes (312) of the foothills and parkland. Also occurs on streambanks, bogs and wet places in the mountains (199). In Alberta, it is found in association with the following grasses in alpine areas: Poa alpina, Poa arctica, Trisetum spicatum, Festuca saximontana, Festuca brachyphylla, and Festuca baffinesis (455). Noted growing at up to 3 270 m in Wyoming (18).

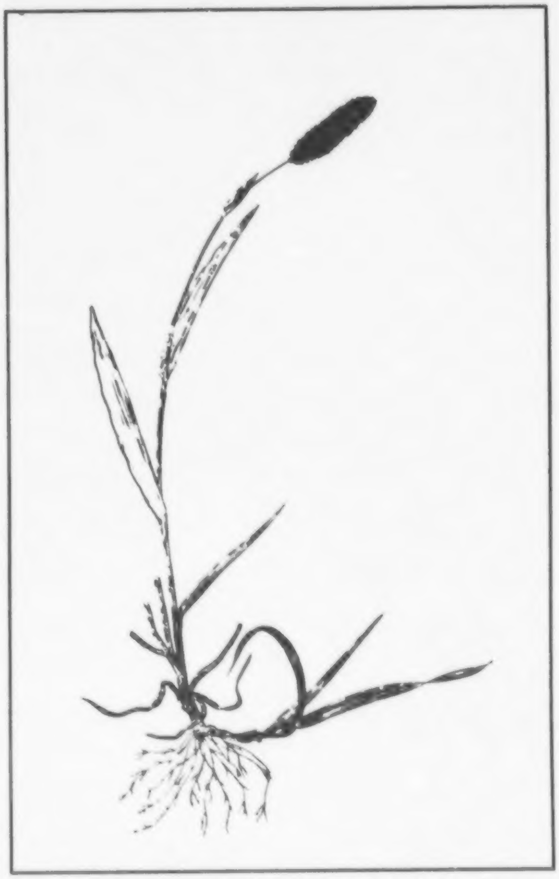
TOLERANCES

Soil Preferences

Will tolerate poorly developed alpine soils, but generally found on Brunisolic soils with textures ranging from sandy loam to silty clay loam. Prefers moderately well drained to imperfectly drained sites. Also observed to favor moist locations (D. Walker, pers.comm.).

Nutrient Requirements

Presumably it has minimal nitrogen requirements since it grows on alpine soils deficient in nitrogen (209).



Soil Reaction

Has been used successfully on acidic mine spoils (185). Grown successfully on acidic mine spoil in alpine areas of Montana when supplied with lime and other amendments (75). Also found on soils developed from basic parent materials.

Soil Salinity

Will not tolerate excessive salinity.

Drought

Presumably drought tolerant because of its growth on open alpine slopes with a dry south exposure.

Heavy Metals and Hydrocarbons

No specific tolerances noted in the literature reviewed.

Shade

Presumably relatively shade intolerant because of its association with alpine habitats. Will withstand minor shading.

Grazing or Mowing

High root:shoot ratio allows sufficient reserves to regenerate after grazing on native ranges.

Susceptibility to Disease and Insect Damage

No specific susceptibilities noted from the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Grows in solitary tufts (435) and may not be effective by itself for extensive erosion control, although fibrous roots can promote sod formation.

Adaptation to Disturbance

Colonizes bare soils (185). In Montana, alpine timothy is noted as an active colonizer on disturbances in alpine habitats (76).

Competitive Ability

Moderately aggressive on favored locations. Compatibility with other alpine species is good.

Commercial Value

It is entirely an alpine pasture grass, not only because it grows in places inaccessible to harvesting equipment, but because its low growth habit makes it difficult to mow and gather (506). On alpine ranges in Wyoming and Colorado, alpine timothy is second only to hairgrass (*Deschampsia caespitosa*) in importance according to its range, abundance, amount of herbage produced, and use by domestic sheep (60).

Palatability and Nutritive Value

Readily eaten by all classes of livestock (506) and by grazing ungulates.

Seed or Planting Stock Availability

Development of seed stocks is currently underway although no seed is presently available through commercial seed dealers.

Methods and Ease of Establishment

In Montana, alpine timothy has been grown successfully in the greenhouse (76). First year survival of transplants on reclaimed acid alpine mine spoils was better than the average of all species tested. Results with seeding alpine timothy here were also favorable (75). Survival rate of transplanted seedlings in Alberta ranged from 96% to 100%, in two different samples (453). In alpine habitats, recommended for seeding in September and October (323).

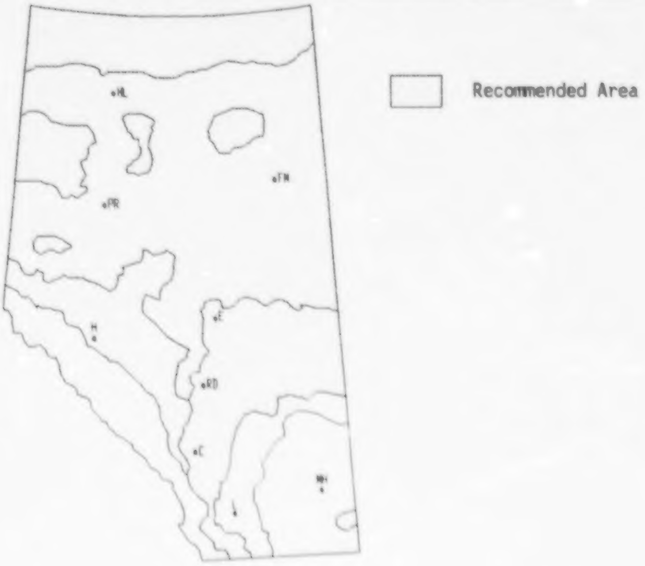
Current Status for Reclamation

Current use for reclamation is not widespread, (455, 453, 379). Recommended for revegetation of alpine ranges and wildlife habitats in Alberta (435). However, performed poorly after six years in mix trials in the subalpine east slopes region of the Rocky Mountains on topsoil and overburden (705). Local collections also performed poorly at Banff (1 390 m) (732). Alpine timothy did reasonably well at Fort McMurray in five years of testing on amended tailings sand (705). *Phleum alpinum* gave the best results in establishment and winter survival in revegetation trials on disturbed land in the western Canadian arctic and did equally well on peat and mineral soils (209). Alpine timothy has been used with some success for revegetation of high-elevation mine wastes in the United States (75, 76). First year results of revegetation on mine spoil in Montana at 2 950 m ASL indicated that density of a native species mix (seed collected locally), including *P. alpinum*, was significantly higher than for an introduced species mix under all treatments (74). Similar tests on lime, fertilizer and manure amended acid mine spoil at 3 000 m ASL in the subalpine-alpine transition zone area in Montana indicated that alpine timothy was among the must successful species. However, without these amendments, poor growth resulted (75).

Alpine timothy is a high elevation grass with wildlife and rangeland value. Other characteristics useful for reclamation include good colonization ability and establishment (in field trials) by seed or transplantation of seedlings.

Phleum pratense

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No ___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid	3.5				
pH Tolerance Base				X	
Winter Hardiness			X		
Erosion Control			X		
Persistence		X	X		
Palatability		X			
Browse Tolerance			X		
Moisture Preference	Moist.				
Soil Preference	Loam to clay textured, organic soil, well drained.				

Phleum pratense L.

SPECIES BIOLOGY

Taxonomy - Timothy

Origin and Range

Introduced grass. Native to Europe (312). Found throughout North America. Partly naturalized in many inhabited areas (214).

Growth Habit

Erect bunchgrass 40 to 90 cm tall, with shallow, fibrous roots extending to more than 1.2 m (138, 385).

Nitrogen Fixing - None

Longevity

Short-lived, cool season (639) perennial grass (391, 47). Long-lived in cool, humid and subhumid regions (67). Winter hardy (183). Poor reseeding at higher elevations causes stands to die out after 5 or 6 years (41).

Self Propagation

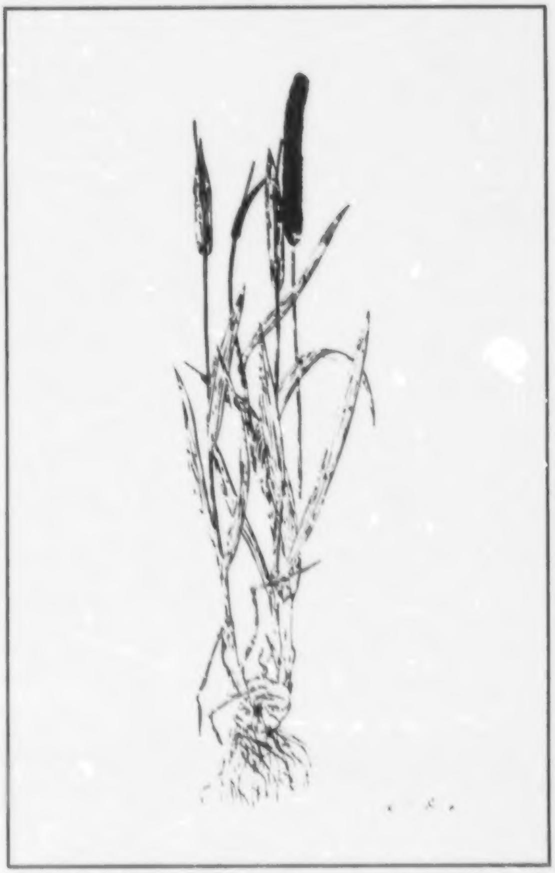
By seed. Its natural reseeding ability is considered moderate, and it displays no apparent ability to reproduce vegetatively (338). Viable seed is not produced at higher elevations (41), though viable seed is produced at 2 100 m in southeastern B.C.

Ecological Setting

Commonly seeded for hay and pasture in the foothills and parklands (47). Found in the lower subalpine. Usually it does not produce viable seeds at higher altitudes (41, 185), although it usually is incorporated into high altitude seeding mixes (41, 131, 106). Seeded at elevations to 4 000 m ASL in Colorado (73, 462), 2 730 m ASL in Wyoming (18), and 1 070 m ASL in Alberta (380). Requires 40 cm (639) to 45 cm (138) of precipitation.

TOLERANCES

Soil Preferences



Generally recommended for growth on loamy textured material (423). Timothy was included as part of a seed mix for moist, moderately well to well drained soils (83). "Engmo" timothy was recommended for seeding of disturbed soils in permafrost areas (79). Tolerance of organic soils has been indicated (436). The optimum slope for growth is 0 to 8%. Optimum soil depth is more than 60 cm. Fair growth has been achieved on sandy soils, good growth on loamy and clayey soils (447).

Nutrient Requirements

Regarded as a species with high nutrient requirements (466).

Soil Reaction

Timothy is regarded as acid tolerant (436). It has been identified as a successful species on acid (pH 3.5 to 5.3) mine wastes (overburden) treated with lime (209). It has been recommended for growth on mine spoil with a pH range of 5.6 to 7.3 (423). The lower pH limit for growth has been estimated at 4.5 (346, 123).

Soil Salinity

Considered to have a low tolerance to salt, in the range of 0 to 4 mS/cm (247).

Drought

Does not tolerate drought or high temperatures (183). Timothy requires considerable moisture to maintain itself. When annual precipitation is less than 45 cm, other grasses will produce more and better hay (138). Poor recovery under limited moisture conditions (183).

Heavy Metals and Hydrocarbons

Timothy has medium tolerance to oil (282). Growth tests on pyritic uranium tailings indicated that timothy produced well, but is susceptible to black discoloration, which causes it to become dormant (318). No other susceptibilities or tolerances have been noted.

Shade

Categorized as shade tolerant, and well suited to seeding under trees (340).

Grazing or Mowing

Not resistant to close, continuous grazing (183).

Susceptibility to Disease and Insect Damage

No susceptibilities were noted in the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

In the Alberta foothills, "Climax" produced the greatest cover on raw coal mine overburden and on overburden topdressed with mineral soil. It was rated as the most promising species for rapid erosion control (10). Elsewhere, it has been rated medium for soil stability (338).

Adaptation to Disturbance

Observed to be a pioneer on Alberta mine spoils.

Competitive Ability

Timothy will spread from cultivated fields into adjacent rangelands (368). Good adaptation to disturbance (338).

Commercial Value

Used for hay, pasture, and silage throughout Canada. Some erosion control capability.

Palatability and Nutritive Value

Palatable and nutritious (183), and considered valuable hay grass. Used particularly for spring and fall pasture by livestock (395). Foliage used as forage by some grazing ungulates (245), and seed used by birds (346).

Seed or Planting Stock Availability

A large number of varieties are available (139) for different ecological settings. Commercial varieties (and certified seed) are available in Canada including: "Astra", "Bounty", "Champ", "Clair", "Climax", "Drummond", "Itasca", "Milton", "Toro", "Basho", "Pronto", "Richmond", and "Timfor" (138). Seed supplies are adequate, but are considered relatively high priced (132). Approximately 1 300 000 seeds/lb (639).

Methods and Ease of Establishment

Establishment by seed has been rated very good, and by transplanting it has been rated good (338). Fall/spring seeding at a rate of 1 lb PLS/ac has been recommended (639). Its ability to establish fall stands quickly makes timothy valuable in mixtures with slower growing species (340). Timothy is judged to be a species which establishes well, but is not persistent in subalpine revegetation. Seedling vigour is good in the subalpine. Because timothy does not produce viable seed at higher elevations, stands begin to die out after 5 or 6 years (41). In general, it provides rapid emergence, early spring growth and late fall growth (436). Successful growth of timothy has been established with hydroseeding techniques on road embankments at high altitudes (162).

Current Status for Reclamation

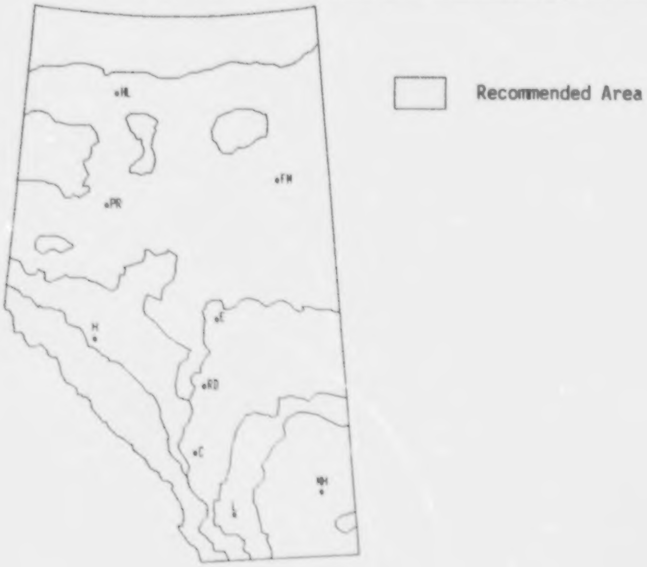
Revegetation of disturbed lands in Alberta includes successful revegetation of coal mine wastes in the Rocky Mountain foothills in Alberta (272, 197, 378) and in central Alberta (304). To date, use of timothy for high altitude reclamation has been characterized by mixed success, with good establishment indicated near Grande Cache (272) and unsuccessful growth relative to other grasses in the Crowsnest Pass area at elevations 1 950 m ASL

(377), both involving revegetation of coal mine waste. Timothy performed well above and below treeline (at 1 500 m ASL) in revegetation of coalfield disturbances in northeastern British Columbia (including alpine tundra and alpine forest habitats) (143). Similarly, timothy was successfully incorporated into species mixes for coal mine reclamation on lands in the montane and subalpine zones (1 650 m to 2 200 m ASL) in the Rockies of southern British Columbia (494), and as high as 2 950 m ASL in Montana (74). "Engmo" provided relatively good first and second year cover in tests in the arctic tundra and then declined rapidly due to winterkill (644). Timothy provided good growth on waste rock, overburden, and tailings at metal mines in the southern interior of British Columbia (143). On growth tests on pipeline berms in the Northwest Territories, "Climax" showed moderate growth at selected sites relative to other grasses; in other areas, it produced most of the combined first year grass growth (459). On the Norman Wells to Zama Pipeline "Climax" had relatively good cover and vigour in mixed seedings for the first two years and then declined rapidly (644). At Fort McMurray "Climax" did well for 2 to 3 years in a grass-legume mix on amended tailings sand soil and overburden, and then declined rapidly (643). In the Swan Hills, "Climax" remained co-dominant with "Boreal" creeping red fescue in a grass-legume mixture ten years after seeding (646).

Timothy is a common component of hay crops and revegetation species mixtures. Attractive features for revegetation include livestock forage value, commercial availability of seed, and rapid establishment. Suited wherever reclamation objectives indicate an agricultural land use (hay and pasture crop), as well as for interim erosion control seeding.

Poa alpina

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid		X			
Base					
Winter Hardiness	X				
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance		X			
Moisture Preference	Dry to moist.				
Soil Preference	Gravel to loam textured, well drained.				

Poa alpina L.

SPECIES BIOLOGY

Taxonomy - Alpine Bluegrass

Origin and Range

Native. Circumpolar distribution; important over arctic and alpine regions of North America. Extending south to Quebec, northern Michigan, and the alpine summits of Colorado, Utah, Washington, Oregon, and Mexico (214, 199).

Growth Habit

Erect, densely tufted bunchgrass, 10 to 30 cm tall (312).

Nitrogen Fixing

None; but has been shown to be associated with N_2-fixing bacteria (601).

Longevity - Cool season (639) perennial (199).

Self Propagation - Seed.

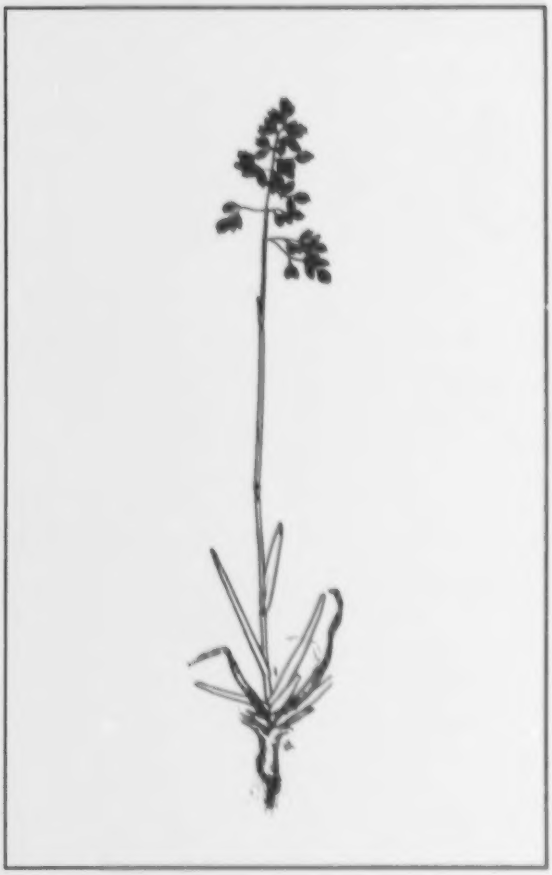
Ecological Setting

Common in the mountains (312) on dry slopes, meadows, rocks (214), also moist alpine slopes (50). Associated with many alpine plant communities including tufted hairgrass (Deschampsia caespitosa) in Colorado and Wyoming (60) and as part of Carex nigricans-Poa alpina-Erigeron peregrinus communities of alpine alluvial sites in British Columbia (355). Recorded at 3 600 m ASL elevation in Wyoming (18). In the eastern Canadian arctic, Poa alpina is found in association with Poa rigens and Polygonum viviparum in sheltered valleys on well drained fine sandy limestone (177). Requires 50 cm of precipitation (639).

TOLERANCES

Soil Preferences

Will grow on bare soils, acidic mine spoils (185), and talus slopes (209). Also noted growing on (alpine) alluvial sites with loamy soil over fast draining gravel (355).



Nutrient Requirements

In general, application of inorganic fertilizers to native soils favors short-lived grasses and annual weeds, at the expense of long-lived perennials (455). This is thought to be applicable to alpine bluegrass.

Soil Reaction

Noted growing on acidic mine spoils in Montana (185, 76).

Soil Salinity

Will tolerate mildly saline soils.

Drought

Presumably drought tolerant.

Heavy Metals and Hydrocarbons

No specific tolerances noted in the literature.

Shade

Presumably shade intolerant.

Grazing or Mowing

Apparently resistant to grazing (355).

Susceptibility to Disease and Insect Damage

No specific insect pests noted in literature reviewed. Found to be susceptible to snow mold although some strains appear resistant (J. Weijer, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Its ability to colonize disturbances and its high root:shoot ratio make this species a good candidate for soil building, although the bunched habit of alpine bluegrass prevents it from being very effective at surface runoff control.

Adaptation to Disturbance

Alpine bluegrass is described as an active colonizer on virtually all disturbances in alpine environments (76). Considered to be relatively less susceptible to trampling by recreationists and horses than most other alpine vegetation; noted thriving on trampled soil (355).

Competitive Ability

Competitive ability depends on the genotype (D. Walker, pers.comm.). Observed to be not as aggressive as other alpine and subalpine grasses.

Commercial Value

Alpine grassland ranges with Poa alpina are grazed by domestic sheep in Colorado and Wyoming (60).

Palatability and Nutritive Value

Rated high for palatability (427), alpine bluegrass is among those grass species preferred by domestic sheep on alpine rangelands in Montana (60); also used by grazing wildlife.

Seed or Planting Stock Availability

A limited supply of native seed stock is usually available. Approximately 1 000 000 seeds/lb (639). "Gruening" alpine bluegrass was released from Alaska for production in 1987 (738).

Methods and Ease of Establishment

In Alberta, Poa alpina seeds have been collected in the field and germinated in growth chambers. Nursery plants grown in containers derived from these seed collection efforts have been transplanted to disturbed subalpine sites, many on coal mine waste with excellent survival of the transplanted seedlings; the average number of seedheads was significantly higher on disturbed plots (455, 453, 379). In Montana, Poa alpina was also successfully grown under greenhouse conditions (79). Seedlings transplanted to alpine mine spoils survived and were actively growing one year later (74). Alpine bluegrass recommended for seeding in Colorado at elevations above 2 400 m ASL (427). Fall/spring seeding at a rate of 1 lb PLS/ac has been recommended (639).

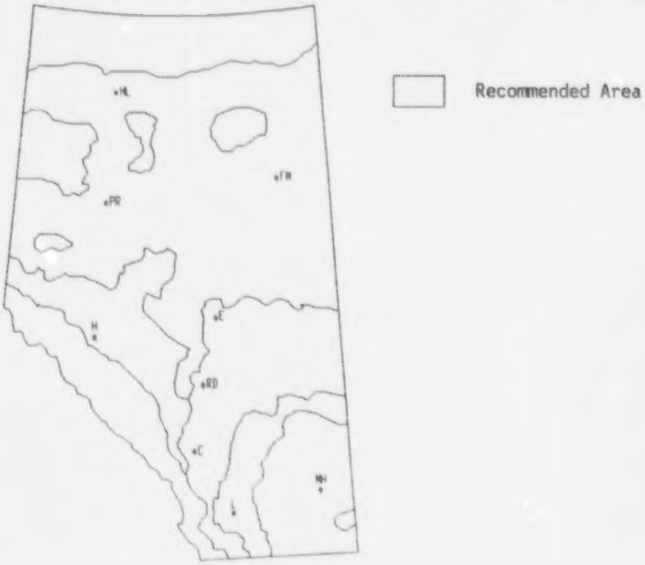
Current Status for Reclamation

The results of preliminary seeding and transplant studies involving establishment of Poa alpina on disturbed lands in alpine and subalpine areas of Alberta and Montana (76, 75, 455, 453, 379) indicate the suitability of alpine bluegrass for reclamation of high elevation disturbances. Test seedings in alpine and subalpine sites in the eastern slopes region of Alberta and in the Upper Mackenzie region of the boreal forest (latitude 63° N) had high survival and vigour after three years (723, 644). However, in mix trials in the eastern slopes alpine bluegrass did poorly after six years (705). At Fort McMurray alpine bluegrass did relatively well after five years on amended tailings sand (705). As a native species and a component of high elevation wildlife ranges, Poa alpina fulfills several criteria for species selection in revegetation planning.

First-year results of growth trials on alpine mine disturbance in Montana indicated that a native species grass mix, including alpine bluegrass, produced greater cover than an introduced species mix under all experimental treatments (74). The Alberta Environmental Centre is currently selecting a number of lines of Poa alpina for potential commercial production and fitness for reclamation (655).

Poa compressa

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance			X	X		
Salt Tolerance				X		
pH Tolerance	Acid		X			
	Base			X		
Winter Hardiness			X	X		
Erosion Control			X			
Persistence			X			
Palatability			X			
Browse Tolerance			X			
Moisture Preference		Wet to dry.				
Soil Preference		Loamy to clay textured, tolerates coarse texture.				

Poa compressa L.

SPECIES BIOLOGY

Taxonomy - Canada Bluegrass

Origin and Range

Variously described as a native (138) or introduced (214, 312) grass, found from Alaska to Newfoundland, south through much of United States (507).

Growth Habit

Medium tall, erect sod-forming grass with a dense creeping root system, long rhizomes and numerous fibrous roots extending deep into the soil. About 20 to 70 cm tall (138, 312). High root:shoot ratio. Low growth habit (436).

Nitrogen Fixing - None

Longevity

Long-lived, cool season (639) perennial.

Self Propagation

Seeds. Also spreads vegetatively by rhizomes, rated very good in this respect (338).

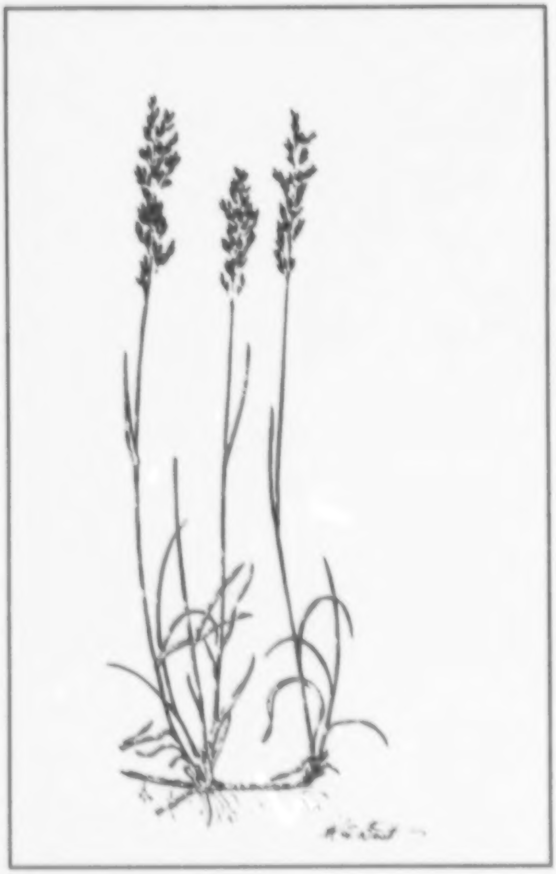
Ecological Setting

Widely used for pastures and as a substitute for P. pratensis in lawns (507). Commonly found on waste ground, roadsides, meadows, and open woods (312, 507). Found occurring in a wide range of wet to dry prairie stands in southern Michigan (413). Found growing as high as 2 460 m ASL on moist sites in Wyoming (18). Transplants successfully growing on mine spoils at 3 000 m ASL (75) in Colorado. Requires 45 cm of precipitation (639).

TOLERANCES

Soil Preferences

It grows on a variety of soils of low fertility or poor drainage (138). It occurs specifically on low fertility prairie and forest soils in the Pacific northwest and great basin states (179). Optimum slope for growth is 0 to 8%; optimum soil depth 30 to 60 cm. Good growth on loamy and clayey soils, and fair growth on sandy soil, in Colorado (446). In the Mackenzie River Delta area, vigour of Canada bluegrass was rated good in terms of overwintering ability on both mineral and organic soils. It provided good cover in seeded areas after the second year of growth (486). Canada bluegrass showed good survival and growth on disturbed tundra and gravel bars in Alaska (284). Significantly higher survival on mineral soil than on organic soil in the Northwest Territories (111).



Nutrient Requirements

Has tolerance for low nutrient situations (436).

Soil Reaction

Spreads well on acidic mine spoils (185). Seedlings showed good establishment (first year growth) on acid spoils in Montana (75).

Soil Salinity

Shows moderate tolerance to soil salinity.

Drought

Considered to be drought tolerant (498, 476).

Heavy Metals and Hydrocarbons

No references noted.

Shade

Moderately tolerant of at least partial shade.

Grazing or Mowing

Noted for its resistance to grazing (138).

Susceptibility to Disease and Insect Damage

No specific pests or diseases noted in literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Used for cover and erosion control on roadsides, roadcuts and fills, borrow pits, dam sites, and recreational areas (179). Its ability to persist and produce on poor quality soils makes it useful for regrassing eroded areas (506). Able to stabilize sandy loam soil (476).

Adaptation to Disturbance

Noted for its resistance to trampling (138). In general, good adaptation to disturbance (338). Able to cope with blowing sand (132). Persistent; reinvades improved pasture situations (179).

Competitive Ability

Subject to competition from other species: Canada bluegrass grew well in single species tests at 2 100 m ASL, but was virtually absent in grass-legume mixes (497).

Commercial Value

Pasture grass for livestock (138), erosion control (179). However, it is difficult to eradicate and rapidly reinvades improved pasture seedings unless heavy management is practiced (179).

Palatability and Nutritive Value

Used as a pasture grass. Under some conditions, it is fairly productive for hay (138). Observations indicate that Canada bluegrass has some natural curing properties as livestock, particularly horses, maintain their condition when pasturing on it during the autumn and early winter (506). Generally quite palatable from early spring until late fall (138).

Seed or Planting Stock Availability

Seed of "Ruebens" and common Canada bluegrass is commercially available. Approximately 2 500 000 seeds/lb (639).

Methods and Ease of Establishment

Establishment by seed rated as good; establishment by transplanting rated as very good (338). In Colorado, it has low seedling vigour when seeded on disturbed subalpine sites, but is persistent once established, spreading by rhizomes (41). Fall/spring seeding at a rate of 1 to 2 lbs PLS/ac has been recommended (639). Field studies in Montana indicate good survival of Canada bluegrass transplants on acid spoils in the subalpine and alpine area (75).

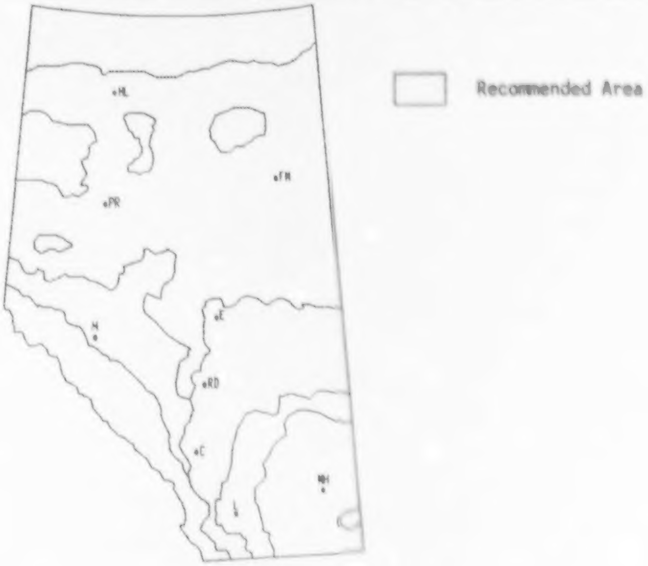
Current Status for Reclamation

Canada bluegrass seeded on a coal exploration site in Alberta (at 1 950 m ASL elevation) showed good to very good first year growth, but had heavy wintering losses (377). Marginal first year success was noted on coal mine waste at 1 070 m ASL in the Crowsnest area (380). Performance after six years had not improved (705). In tests near Banff (1 390 m) Canada bluegrass had good vigour after four years (732). On disturbed peat and mineral soils in the western Canadian arctic and Mackenzie Delta, "Canon" Canada bluegrass showed good establishment and winter survival for five years before declining (644). In the Northeast coal block of British Columbia, growth on exploration disturbances was rated as moderate above treeline (1 370 m ASL) and excellent below treeline (70). Canada bluegrass had the poorest emergence of all species studied on coal mine wastes at Hat Creek, British Columbia (439). In the oil sands, "Ruebens" maintained high vigour and relatively good growth after five years testing on amended tailings sand (705).

Canada bluegrass is generally recommended for revegetation of poor soils in dry climates throughout North America. In Canada, it is frequently included in grass-legume mixtures at mine waste reclamation projects, though with mixed success. Its spreading (rhizomatous) habit, apparent tenacity, and erosion control ability are favored for revegetation. It is useful where reclamation objectives specify agricultural land use, particularly livestock pasture. Many sources indicate slow establishment and relatively poor first year growth on agricultural and disturbed soils. It generally provides good cover and long term growth after the first year, however.

Poa pratensis

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No ___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance				X	
pH Tolerance Acid			5.5		
pH Tolerance Base			X		
Winter Hardiness	X	X			
Erosion Control	X				
Persistence		X			
Palatability		X	X		
Browse Tolerance		X			
Moisture Preference	Moist to dry, tolerates wetness and flooding.				
Soil Preference	Medium texture, well to imperfectly drained.				

Poa pratensis L.

SPECIES BIOLOGY

Taxonomy - Kentucky Bluegrass

Includes *P. alpigena* (Fr.) Lindm., *P. agassizensis* Bovin & D. Love

Origin and Range

Introduced from Eurasia. Widespread in most of temperate Canada and all but the southeastern U.S. (507). It occurs on the prairie grassland of central and northern Alberta (312). It has invaded rangelands to such a degree that it is often considered to be a native (506). There are a large number of varieties (70) licensed for use in Canada (138).

Growth Habit

A sod-forming grass with culms 30 to 80 cm tall (312). It is rhizomatous and produces dense sod under favorable conditions (391). It has a shallow root system subject to drying out in dry weather (340).

Nitrogen Fixing - None

Longevity

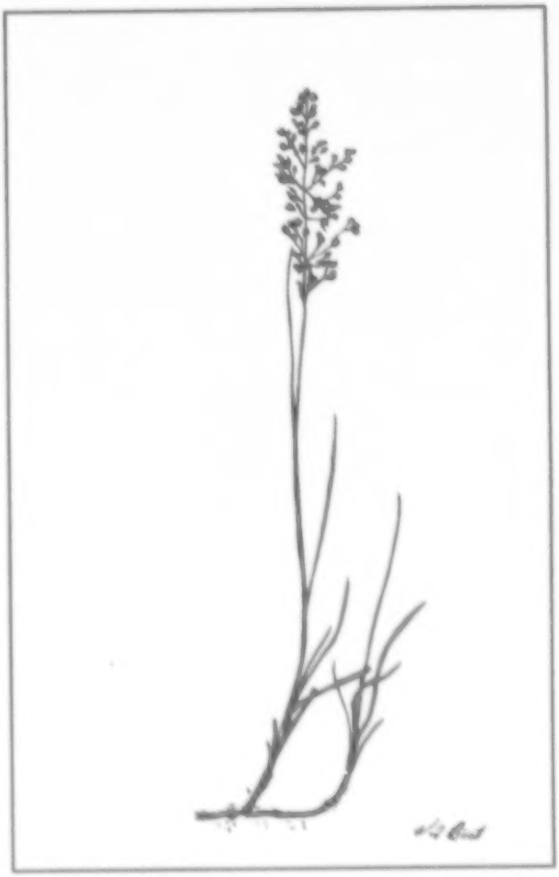
Long-lived, cool season (639) perennial (391). Kentucky bluegrass seeded at 3 120 m ASL in southwestern Montana persisted or increased over a ten year period (193). It is persistent in most areas of the United States including Alaska (37). Several varieties have excellent winter hardiness (5, 138).

Self Propagation

Seeds. The formation of seed without fertilization (apomixis) is a common characteristic of Kentucky bluegrass varieties, consequently pollinated seeds are rare (138). Kentucky bluegrass produces abundant seed (138). Also spreads by rhizomes (391).

Ecological Setting

Roadsides and waste areas to dry or moist prairies and woodland (507), meadows and lawn (312). An important range grass for cattle throughout the aspen parkland in Alberta (506). Kentucky bluegrass is adapted to a cool, humid climate and grows on moist sites in meadows, pastures, fields, and open woods (138). Requires 45 cm of precipitation (639). It requires more moisture than is available over most of the prairies and thus has never been popular for pasture purposes where rainfall is less than 50 cm annually (506). Areas best suited are moderately moist with precipitation greater than 38 cm, moderately cold to cold and at elevations greater than 2 167 m ASL (427). Kentucky bluegrass requires cool, moist conditions for optimum growth; it therefore grows best on northern exposures or at higher elevations (37). Kentucky bluegrass is an important component of the sandhills tallgrass prairies in North Dakota (469).



TOLERANCES

Soil Preferences

Kentucky bluegrass grows best in soils of medium texture (138). It is adapted to a range of soil moisture regimes from well drained through to imperfectly or poorly drained. It is adapted to a wide range of soil groups and soil textures. Kentucky bluegrass has good tolerance to wetness and flooding (5). Kentucky bluegrass performed better on mineral soil than organic soil when seeded on a disturbed site near Norman Wells, N.W.T. (110). Growth on sandy soil is fair whereas growth on loamy and clayey soil is rated as good (447).

Nutrient Requirements

It grows best in soils of high fertility (138), and fertilizer requirement has been rated as high (5). Kentucky bluegrass has rather exacting nutrient requirements and it responds favorably to high nitrogen fertilization (37).

Soil Reaction

It has been noted as having only fair tolerance to soil acidity (5); soil pH must be at least 5.5 for good growth (712). Kentucky bluegrass does well on soils of limestone origin (37).

Soil Salinity

Kentucky bluegrass has poor tolerance to soil salinity (424).

Drought

It is not drought resistant (138). Yields can be increased with irrigation (391). It may go dormant during dry weather (37).

Heavy Metals and Hydrocarbons

Kentucky bluegrass was the best agronomic grass on metal tailings (Pb, Ag, Zn) in the Yukon after three years (611). At the site of a diesel spill near Whitehorse, Kentucky bluegrass was surviving where there was not direct contact with the diesel, but where diesel was present in the soil (216).

Shade

Kentucky bluegrass will grow in slightly shaded situations, if moisture and nutrients are available, but it grows better in open sunlight (37).

Grazing or Mowing

Kentucky bluegrass has a rapid recovery rate after cutting (5).

Susceptibility to Disease and Insect Damage

Various varieties are subject to stripe rust, leaf rust, stem rust, powdery mildew, leaf spot, Helminthosporium, red thread, and stripe smut (138).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

An excellent grass for controlling erosion and promoting soil stability (340, 338). Kentucky bluegrass produces a dense rhizomatous sod under favorable conditions (37). It has high ground cover production (436) and a good rate of spread (424, 338).

Adaptation to Disturbance

Tolerant of trampling. Its short foliage and tough sod features make it useful for seeding camp, picnic areas, and other turf areas (340). Kentucky bluegrass is common throughout the moist prairies, where it has escaped from lawns and pasture (78); it is an early colonizer of old fields in adapted areas (145). Spring burning tends to reduce vigour and cover (145).

Competitive Ability

Kentucky bluegrass is slow to establish when seeded in a mixture, but grows well with white clover (Trifolium repens), or other legumes (391). Compatibility has been rated as good (436, 5). Kentucky bluegrass seeded on tailings sand slopes in northern Alberta was dominant at low fertilizer rates but at higher rates it was unable to compete with larger smooth brome grass and the wheatgrasses (359).

Commercial Value

An important pasture grass (391). Also important for hay crops (138). It is used extensively in mixtures for the production of general turf and highly developed lawns throughout Canada (138).

Palatability and Nutritive Value

Kentucky bluegrass is palatable and very nutritious for cattle (19) during the spring; however, unless it is kept grazed, it soon becomes stemmy and unpalatable (506). It is relatively unproductive in mid-summer when it goes dormant during dry weather (391). Forage value for mule deer has been rated as fair, while for small mammals forage value has been rated as good (447). Poa spp. received medium use by moose and bighorn sheep, and high use by mule deer and elk (144).

Seed or Planting Stock Availability

Seed of Kentucky bluegrass is available

commercially. Over twenty licensed cultivars are available: "Amazon", "Baron", "C-1", "Delta", "Fylking", "Kenon" (no certified seed available), "Merion", "Nugget", "Park", "Prato", "Primo", "Sydsport", "Troy", "Ram 1", "Regent", "Windsor", "Banff", "Birka", "Bono", "Cheri", "Dormi", "Majestic", "Touchdown", "Victa" (138). Approximately 2 [illegible] 000 seeds/lb (639).

Methods and Ease of Establishment

In mixtures, this plant is slower to become established than most grasses and legumes, not appearing until two or three years after a mixture is seeded (391). Seedling vigour has been rated as fair (5). Establishment by seed and by transplanting has been rated as very good (338). Plants are persistent once established (41). Fall/spring seeding at a rate of 2 to 3 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

Kentucky bluegrass has been used extensively for reclamation in Canada (316). "Troy" and "Nugget" did equally well providing acceptable cover in the first three years in the subalpine on overburden and topsoil in the Eastern Slopes region of Alberta (723). "Nugget" produced better cover on topsoil than on raw overburden (364). At Banff "Nugget" provided adequate short-term (2 to 3 year) cover at 1 390 m before declining (732). In tests in the Mackenzie River Delta (latitude 70° N) "Nugget" has persisted strongly for twelve years without follow-up fertilizer (643). "Regent" had excellent survival and vigour in the upper Mackenzie region of the Boreal Forest (latitude 63° N) after three years. Common Kentucky bluegrass performed poorly in a mix on the Norman Wells to Zama pipeline (644). It also performed poorly in a grass-legume mix at Cold Lake (685). At Fort McMurray, "Nugget" had moderately high plant vigour and cover after five years on amended tailings sand (705). Kentucky bluegrass has been recommended for coal mine reclamation on sites above 1 650 m ASL in southeastern B.C. This species also proved successful in test plots established at 2 200 m ASL in the same area (494). An initial assessment of Kentucky bluegrass seeded on dry mine wastes at 3 mines in southeastern B.C. showed it to have moderate performance on waste rock and poor performance on tailings and overburden (143). Kentucky bluegrass has been recommended as a suitable grass for planting on critical areas in Alaska (5), for tundra sites in the Mackenzie and Yukon Valley and for boreal forest sites (37). It is used extensively throughout the northeastern United States to obtain a fast cover on disturbed land areas (37). It is used in highway roadbank seedings in Alaska and is under experimentation there (298). It has been recommended as suitable for planting in critical sites in northwestern Colorado. Kentucky bluegrass was one of the best grasses tested at several subalpine sites in northcentral and central Colorado. It persisted for at least three years and spread out from the seeded zones (236). Kentucky bluegrass is used for soil stabilization after road construction (176) in Colorado and Wisconsin.

Kentucky bluegrass is a long-lived, sod-forming grass providing excellent soil erosion control, posture and turf over a wide geographic range, preferring medium to heavier textured soils and moist sites. Being slow to establish it should be seeded with a mix on sites requiring immediate protection.

Puccinellia distans

SPECIES SUITABILITY MAP AND SUMMARY TABLE

Recommended Area

Commercially Available: Yes X No ___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	Ncne
Drought Tolerance			X		
Salt Tolerance	X	X			
pH Tolerance Acid				X	
pH Tolerance Base		X			
Winter Hardiness			X		
Erosion Control		X			
Persistence			X		
Palatability			X		
Browse Tolerance				X	
Moisture Preference	Moist to wet, tolerates dry also dry alkeline soils.				
Soil Preference	Loamy to clay texture.				

Puccinellia distans (L.) Parl.

SPECIES BIOLOGY

Taxonomy

Slender Salt-Meadow Grass (78); Alkaligrass (639).

Origin and Range

Introduced from Eurasia. Apparently not very common in Alberta, found occasionally in the southeastern portion of the Canadian prairies. Alaska, British Columbia to Quebec, south to Maryland, Michigan, Wisconsin, and North Dakota; Washington, south to New Mexico and California. Regarded as an introduced weed (214). P. distans intergrades with P. nuttalliana (Schult.) Hitchc. (P. airoides (Nutt.) Wats. and Coult.) which is called Nuttall alkali grass or Nuttall's salt-meadow grass and is a native of western North America (312, 78, 199).

Growth Habit

A short, tufted bunchgrass. Erect or decumbent, generally 20 to 50 cm tall (312, 199, 78).

Nitrogen Fixing - None

Longevity - Cool season (639) perennial (435).

Self Propagation - By seed.

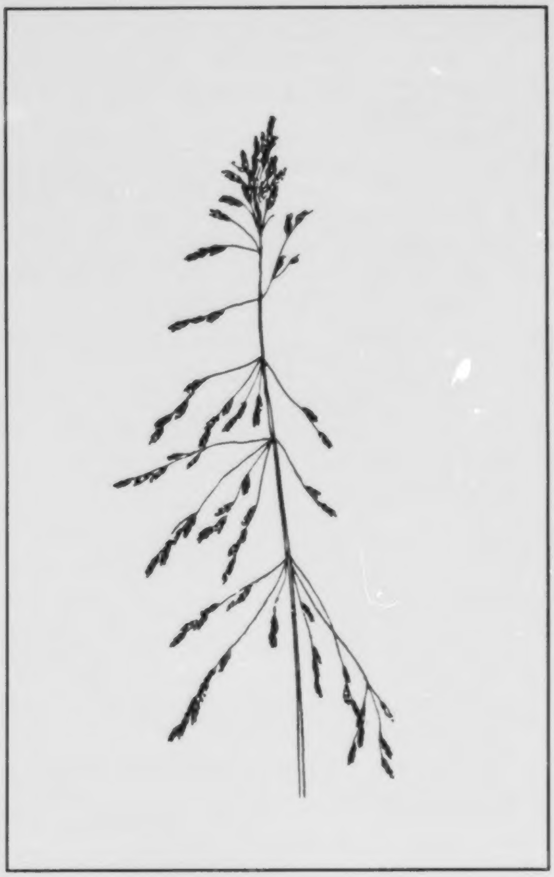
Ecological Setting

Slender salt-meadow grass is found in moist, slightly alkaline flats in the southeastern portion of the Canadian prairies (78). In Alaska, it is found along roads, in yards and waste areas. Nuttall alkali grass is common throughout the prairies in moist saline depressions. Also found in dry to wet alkaline soils. It is often found growing with Distichlis stricta (47). Requires 38 cm of precipitation (639).

TOLERANCES

Soil Preferences

Slender salt-meadow grass prefers moist to wet soils. Optimum slope is 9% to 30% and optimum soil depth is greater than 60 cm. Growth on sandy soil is fair, and growth on loamy and clayey soil is good (446). Although it is usually located on moist soils, some ecotypes do colonize and persist well in drier situations (435).



Nutrient Requirements

Requires low to moderate soil nutrient levels.

Soil Reaction

Slender salt-meadow grass is tolerant of alkaline soils (446).

Soil Salinity

Slender salt-meadow grass is salt tolerant (446). Nuttall alkali grass has very high salt tolerance (361).

Drought

Adapted to physiologically dry conditions, although it is found on moist sites.

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Does not persist if shaded.

Grazing or Mowing

Puccinellia spp. are often severely damaged when grazed (199).

Susceptibility to Disease and Insect Damage

No disease or insect pests noted in the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The ability of both alkali grasses to grow on saline soils may contribute to stabilization and soil building in these sites.

Adaptation to Disturbance

Invades disturbed saline depressions.

Competitive Ability

Not particularly aggressive.

Commercial Value

May be used for forage although not as productive as many other species.

Palatability and Nutritive Value

Puccinellia spp. are generally fairly palatable, but seldom abundant enough to be heavily used except in muddy areas (199). Nuttall alkali grass makes a palatable hay but stands are too sparse to obtain heavy yields. Conflicting evidence indicates that it is common but it is not readily grazed (78). It apparently produces considerable forage in the regions where it is common and a form called "Zawadke" alkali-grass is cultivated in Montana. The forage value of slender salt-meadow grass has been rated as poor for mule deer and game birds, and fair for small mammals. Cover value is poor for mule deer, and fair for gamebirds and small mammals (440).

Seed or Planting Stock Availability

Nuttall alkali grass is sometimes cultivated under the name of "Zawadke" alkali grass (312, 78). "Fults" available in the US (639). Approximately 1 200 000 seeds/lb (639).

Methods and Ease of Establishment

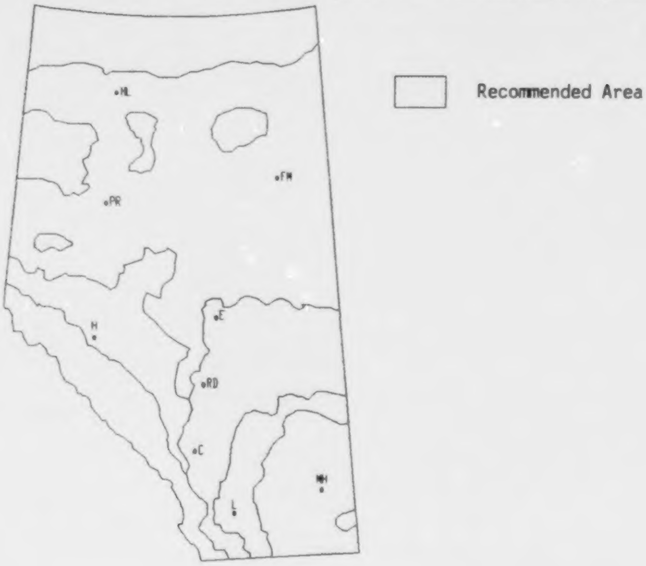
By seed. Fall/spring seeding at a rate of 2 to 3 lbs PLS/1 000 ft^2 (639). No other specific methods of establishment were noted in the literature reviewed.

Current Status for Reclamation

Slender salt-meadow grass has been recommended for long term rehabilitation of disturbed land in northwestern Colorado (446). Some research into the use of P. nuttalliana and P. distans for reclamation is being done at Colorado State University (132). They both have potential for reclamation of alkaline or saline soils in Alberta (435). Nuttall alkali grass, invading disturbed sites at Pinchi Lake mine in British Columbia, has been noted to increase after fertilizer application. The occurrence of this species on harsh tailings has prompted seed collections for further testing (394). Showed excellent survival and vigour after three years in the Upper Mackenzie region of the boreal forest (latitude 63° N) (644).

Stipa viridula

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid					
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control			X		
Persistence			X		
Palatability		X	X		
Browse Tolerance			X	X	
Moisture Preference	Dry to moist.				
Soil Preference	Loamy to clay textured, wide range.				

Stipa viridula Trin.

SPECIES BIOLOGY

Taxonomy - Green Needle Grass

Origin and Range

Native. Found throughout the southern portion of the Canadian prairies and southern B.C. (78). In the U.S. it is found from Wisconsin to Montana and south to New Mexico (183).

Growth Habit

A tall, tufted bunchgrass usually 40 to 80 cm tall (312). It has a fibrous root system, and is fairly deep rooted (392).

Nitrogen Fixing - None

Longevity

Cool season (639) perennial (365). Green needle grass generally flowers when plants are three years old. It requires a certain dry period to flower (467).

Self Propagation

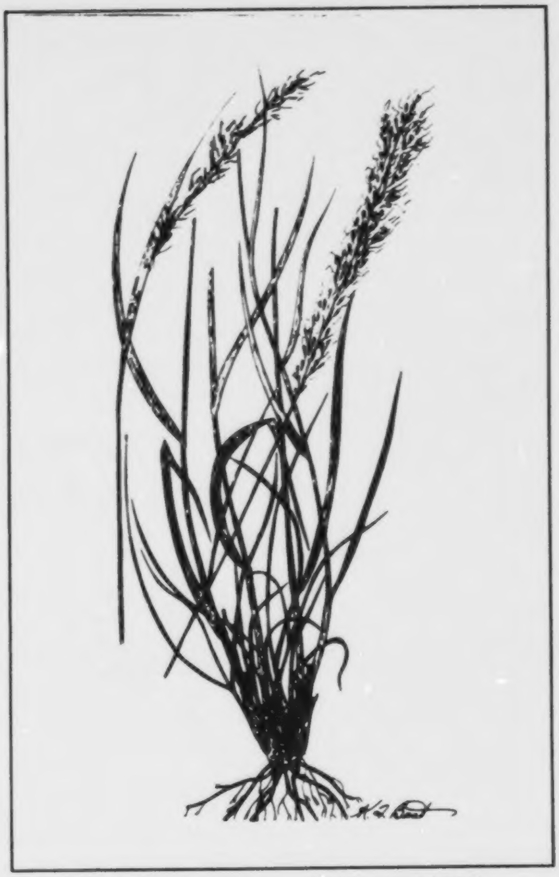
Seed. Shoots originate from tillers (467).

Ecological Setting

Green needle grass is common in the dry prairie grassland (312). Apparently common in moister places and heavier soil throughout the southern part of the Canadian prairies (78). It is most common in areas receiving 38 cm or more mean annual precipitation, but it occurs in areas receiving as little as 25 cm (426). Subalpine needle grass (Stipa columbiana) is a component of the submontane prairie (454). Needle and thread (Stipa comata) is an important component of the mixed prairie (435). It is characteristic of the excessively drained high prairie of eastern North Dakota (465, 170).

TOLERANCES

Soil Preferences



Green needle grass is found on dry to moist, deep fertile soils throughout the prairies (47). It is adapted to a wide range of soil textures but it is more abundant on clay textured soils (426). Planting on loamy or clayey soils was recommended for critical areas in Colorado (424). Growth on sandy soil is reported to be fair, while on loamy and clayey soil, growth is good (446).

Nutrient Requirements

Additions of N fertilizer increased the number of vegetative tillers, but did not affect the number of floral tillers (467).

Soil Reaction

No specific tolerances noted in the literature reviewed, although it is expected to be tolerant of moderately alkaline sites.

Soil Salinity

Green needle grass has poor salt tolerance (424).

Drought

Moderately drought tolerant.

Heavy Metals and Hydrocarbons

No specific tolerances noted in the literature.

Shade

Presumably relatively intolerant of shade. Prefers open sunny locations.

Grazing or Mowing

Needle and thread was found to increase on grazed rangelands in the interior of B.C. (114, 287), but to decrease under increased grazing pressure in the Stipa-Bouteloua prairie of Alberta (389, 390, 122, 392). Deeper rooted needle and thread tended to be replaced by shallow rooted little club moss (Selaginella) and blue grama (Bouteloua) on heavily grazed Stipa-Bouteloua prairie soils (392).

Susceptibility to Disease and Insect Damage

No specific diseases or insect pests noted for this species.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Green needlegrass is a bunchgrass with fibrous roots (47), and is fairly deep rooted (392); therefore, it could be expected to provide moderate erosion protection. It has a fair rate of spread (424).

Adaptation to Disturbance

Invades disturbed sites in areas of adaptation.

Competitive Ability

Moderately aggressive although compatible with other grasses.

Commercial Value

Used extensively as a range forage plant for livestock and wildlife in the southern Canadian prairies and northern prairie states.

Palatability and Nutritive Value

Stipa spp. are one of the most valuable forage grasses on western ranges, both for hay and pasture. In some species (especially S. spartea and S. comata) the seed lemmas are needle-like and injurious to the mouth parts and skin of grazing animals, particularly sheep. They are therefore grazed mainly when young. They are palatable much of the year however (309, 199). Needle and thread is considered relatively poor summer and winter forage compared to bluebunch wheatgrass (Agropyron spicatum) (114). When comparing western wheatgrass (Agropyron smithii), green needle grass (Stipa viridula), blue grama (Bouteloua gracilis) and little bluestem (Andropogon scoparius), western wheatgrass and green needle grass had the highest hemicellulose values throughout the growing season; therefore they were the most digestible. However, they were the most lignified at the end of the growing season. Crude protein content decreased with salinity (231). Forage value of green needle grass is reported to be fair for mule deer and game birds, and good for small mammals (446).

Seed or Planting Stock Availability

Seed is apparently available for released cultivars in the U.S. (426). Two cultivars are "Green Stipagrass", which is superior to common needle grass in forage, seed yields, seedling vigour and regrowth, and "Lodorm" which is relatively expensive (D. Walker, pers.comm.) (426). These are not licensed in Canada. Approximately 181 000 seeds/lb (639).

Methods and Ease of Establishment

Green needle grass has a typical purity/germination of 97/24% (132). Seed of green needle grass is very dormant. Only about 4% of its seed germinates without pretreatment (455). Ease of establishment of green needle grass has been rated as good (424). Fall seeding at a rate of 8 to 10 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

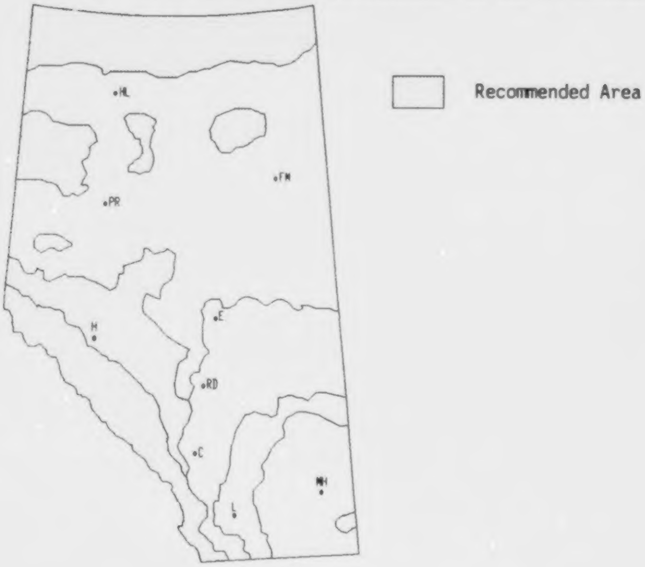
Subalpine needle grass (Stipa columbiana) collected from a subalpine site in Alberta (Pigeon Mountain) had good survival after three years on several alpine and subalpine sites in Alberta (723). Survival tended to be higher on undisturbed sites (84%) when compared to disturbed sites (64%). This was attributed to better soil moisture conditions on the undisturbed site (184). Subalpine needle grass produced better cover on overburden topdressed with mineral soil than on raw overburden after one year at a subalpine site (Cadomin) in Alberta. The cover after the first year was very low, however (364). Needle and thread has also been suggested for possible use on high pH, high lime and coarse textured soils in the mixed prairie region of Alberta (435).

Green needle grass is used extensively in single seedling mixtures in the northern great plains and for mine revegetation in that same area (426). A survey of 17 mines in the southern great plains coal province (which includes parts of Montana, North

Dakota, South Dakota, Nebraska and Wyoming) indicated that 71% of the mines used green needle grass in their seeding mixtures (31). Subalpine needle grass (Stipa columbiana) seeded at two sites in Utah and Wyoming at 3 000 m and 2 900 m ASL, respectively, produced poor stands after 18 years (213). "Lodorm" green needle grass has proved useful for mine reclamation in the western United States (90).

Trisetum spicatum

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance	X	X	X		
Salt Tolerance				X	
pH Tolerance Acid			X		
pH Tolerance Base			X		
Winter Hardiness	X				
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance	X	X			
Moisture Preference	Dry.				
Soil Preference	Rocky, coarse textured.				

Trisetum spicatum (L.) Richt.

SPECIES BIOLOGY

Taxonomy - Spike Trisetum

Origin and Range

Native. A northern species found from Alaska east to Hudson Bay and Newfoundland. South to the mountains from British Columbia to northern California. Also northern Eurasia (214). A wide ranging species in Alberta (312).

Growth Habit

An erect, fairly tall and tufted bunchgrass (309). Usually 10 to 50 cm tall (312).

Nitrogen Fixing

None; but has been associated with N_2-fixing bacteria (601).

Longevity - Long-lived perennial.

Self Propagation

Mainly by seed but viviparous plants may occur (214).

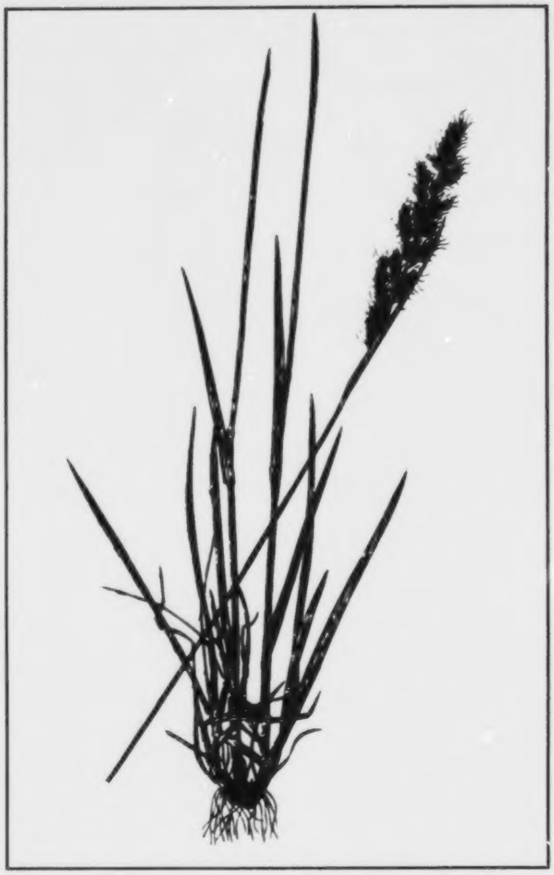
Ecological Setting

Common species of the northern tundra and in dry places in the mountains (18); snow beds to at least 2 000 m ASL in Alaska (214). In Alberta, wide-ranging, particularly in meadows, on slopes and or on ridges (312). It has been found in the Cypress Hills, though it is not a common species of the prairie region (78). Seed has been collected at Mount Rae (2 500 m) and Mountain Park Pass (2 230 m) in Alberta (453). This alpine grass is adapted to an environment where there may be only two months of summer and a frost free period as short as seven days. It is able to grow, flower and set seed at temperatures below freezing (455).

TOLERANCES

Soil Preferences

Spike trisetum is found on dry mountain soils (214), dry rock outcrops and rockslides (209, 427).



Nutrient Requirements

Spike trisetum has been recommended for revegetation of shallow, infertile soils at elevations above 2 665 m ASL in northwestern Colorado (427). Nutrient requirements are probably modest.

Soil Reaction

Spike trisetum has been observed as a pioneer on calcareous, talus slopes in British Columbia (209). It has been recommended for revegetation of mountain soils derived from granitic, basaltic, sandstone or shale materials (427). It can be assumed therefore that tolerances encompass at least mildly alkaline to mildly acidic soil conditions.

Soil Salinity - Low tolerance of saline soils.

Drought

Moderately to extremely drought tolerant. There may be considerable ecotypic variation.

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade - Will grow in partial shade.

Grazing or Mowing - Can withstand severe grazing.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Spike trisetum has a high root:shoot ratio and is thought to be useful for soil building and erosion control.

Adaptation to Disturbance

Spike trisetum was observed as a pioneer on road cuts and fills in the alpine zone of Rocky mountain National Park in Colorado. It was most prominent on slopes where late-lying snow occurred (177). It also invaded test plots established on Harmer Knob (2 200 m) in southeastern B.C. (491). Trisetum sp. has been rated as a pioneer on glacial outwash in the Canadian Rocky Mountains. Spike trisetum has been observed as a pioneer of both north and south-facing talus slopes of the Liard Plateau, B.C. (209). It has also been observed as a pioneer on mine tailings in B.C. (384). Trisetum spicatum subsp. spicatum was a pioneer on dry areas disturbed by animal diggings on the top of pingos near Prudhoe Bay, Alaska (45).

Competitive Ability

Moderately aggressive on favored locations.

Commercial Value

Wildlife forage and erosion control.

Palatability and Nutritive Value

Spike trisetum is an important forage plant in the alpine and subalpine (8). It has high palatability (427). It has been reported to be grazed by Rocky Mountain mule deer (245).

Seed or Planting Stock Availability

Commercial seed is under development, but is not currently available.

Methods and Ease of Establishment

There is ecotypic variation in germination response amongst populations with regard to temperature and light. Germination has been found to be related to the typical temperature at elevations where the population is naturally found. Seed from populations of lower latitudes reach maximum germination more gradually and at higher temperatures than seed from higher latitudes (92). Seedlings transplanted to subalpine sites in Alberta (Sunshine and Coal Valley) had good first year survival (79%) (453). In general, satisfactory germination can be obtained at 20° C (455).

Current Status for Reclamation

The species is not widely used and success to date in high elevation revegetation has been mixed. Spike trisetum had the highest survival in subalpine and alpine sites at Tent Mountain and Adanac (723) but failed in mixture trials at Cadomin and Adanac (705). At Fort McMurray the species did moderately well after five years on amended tailings sand (705).

Spike trisetum has been recommended for planting on critical sites in northwestern Colorado, at elevations above 2 665 m. These areas are cold and moist, with precipitation above 50 cm. Soils are mostly shallow (427). It has proved a successful species for revegetation of disturbed alpine sites in Montana (71). Spike trisetum showed promise in early seeding trials for revegetation of disturbed areas at 3 000 to 3 665 m ASL in Rocky Mountain National Park, Colorado (209).

There is very little information on the autecology of this species. Spike trisetum is found on dry mountain sites so is presumably winter hardy and drought tolerant. Nutrient requirements appear to be low. This species has been successfully established by transplants on disturbed alpine areas in Alberta and the northwestern United States. It shows promise for revegetation of these areas but further research is needed into ecotypic variation.

SPECIES INFORMATION - FORBS

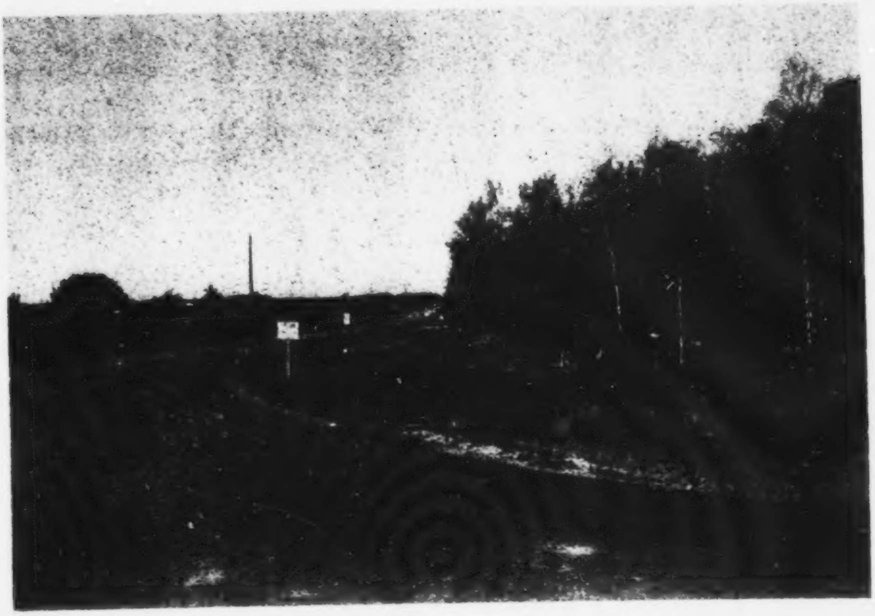


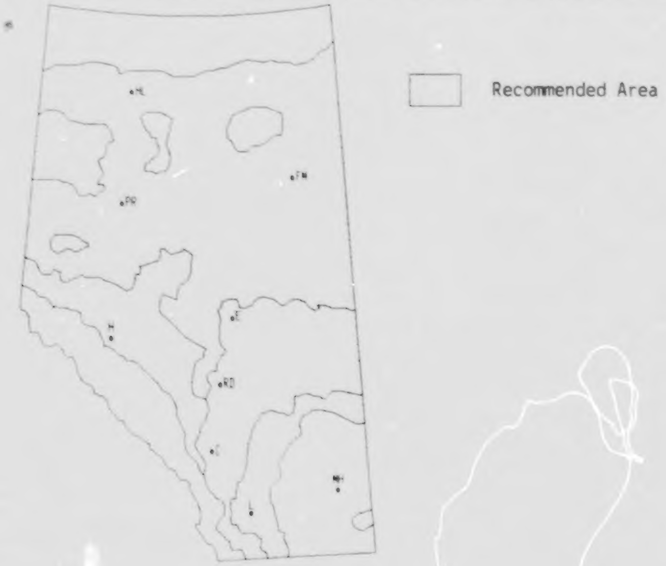
Table 3 Combined performance chart - forbs

Species	Reclamation Suitability Criteria							
	Drought Tolerance	Salt Tolerance	Winter Hardiness	Soil Reaction Tolerance		Erosion Control	Persistence	Palatability
				Acid	Base			
Astragalus cicer	L	M	M	L	M	M	H-M	M
Epilobium spp.	M-L	N	VH-H	M	M	M	M	M
Hedysarum spp.	M	M	U	U	H	L	M	M
Lathyrus ochroleucus	L	L	H	L	L	H	M	M
Lotus corniculatus	M	M	M	H	M	M	H	VH-H
Lupinus argenteus	M	L	H		M	M	M	M-L
Medicago spp.	H-M	M	H-M	M	H	M	M	H-M
Melilotus alba	H-M	M	M	L	H	H-M	L	M-L
Onobrychis viciifolia	M	M	M	L	L	M	L	H-M
Oxytropis spp.	H	M	H	U	M	H	M	L
Trifolium hybridum	M	L	H	M	M	M	L	H
Trifolium pratense	L	L	H	L	M	M-L	L	H
Trifolium repens	L	L	H	M	L	H-M	M	H
Vicia americana	L	L	H	L	L	M	M	H-M

VH - very high
H - high
M - medium
L - low
N - none
U - unknown

Astragalus cicer

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No__

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING			
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base			8.1		
Winter Hardiness			X		
Erosion Control			X		
Persistence		X	X		
Palatability			X	X	
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Medium to coarse texture, well drained.				

Astragalus cicer L.

SPECIES BIOLOGY

Taxonomy - Cicer Milk Vetch

Origin and Range

European (430, 139). Introduced.

Growth Habit

Medium growth habit (41) relative to alfalfa (Medicago spp.). Height is 20 to 25 cm (139). Sodforming legume with leafy, semiprostrate stems (179). Strongly rhizomatous (138). Yellow flowers 10-15 mm long (690).

Nitrogen Fixing

Fixes atmospheric nitrogen (41).

Longevity

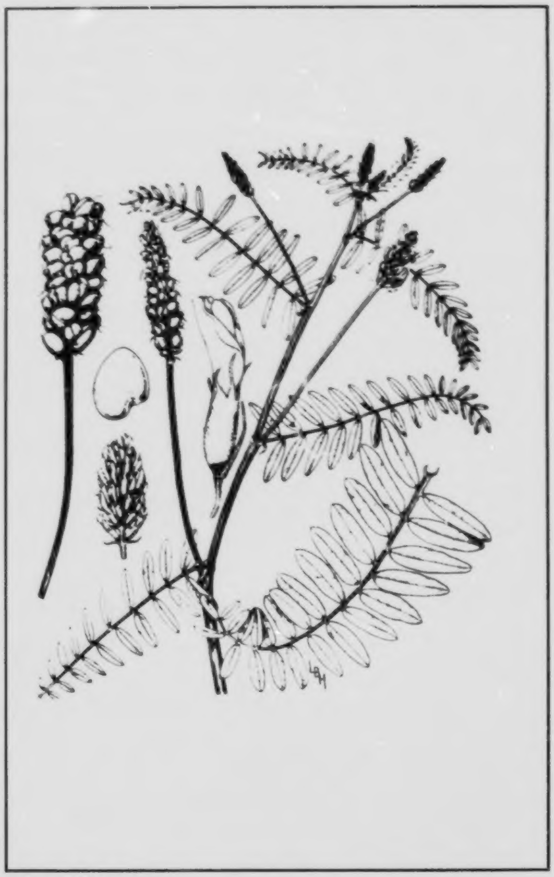
Moderately long-lived, cool season (713) perennial herb (175, 417).

Self Propagation

Predominantly by seeds, but also rhizomatous, thus a thin, initial stand can spread and increase (262). Low germination rate, seedling vigour and emergence rate in Alberta (138), though apparently better elsewhere (339).

Ecological Setting

Similar to alfalfa. In Alberta, it is adapted to a wide range of conditions, but prefers cool, moist sites (179, 391). Apparently not adapted to the upper subalpine (41), although successful growth (relative to other grasses and legumes seeded) has been noted at elevations up to 3 420 m ASL in Colorado (236, 44). Requires 30 to 45 cm of precipitation and is cold hardy (639); 30 to 101 cm (713). In the intermountain region of Utah, Nevada, Idaho, and Wyoming, A. cicer proved to be valuable only on lowland rangelands with over 30 cm precipitation (340); in the Pacific northwest and great basin states, the species is regarded as useful where mean annual precipitation exceeds 35 cm (179).



TOLERANCES

Soil Preferences

Cicer milk vetch is adapted to Chernozemic,Luvisolic and Podzolic soils with coarse textures (391). It is especially well adapted to soils derived from limestone. Cicer milk vetch is used in place of alfalfa in grass-legume mixtures where alfalfa is restricted in growth by shallow soils (179). Established successfully on clay loam soil with moderate to good moisture content, on a northeastern British Columbia pipeline right-of-way (431). Also established on coarse textured subalpine soils, primarily glacial till (236, 44). Achieves its best creeping form on coarse or medium textured soils (138). Good on medium to clayey textures (639).

Nutrient Requirements

Cicer milk vetch and alfalfa established best on tailings sand slopes (oil sands) at the lowest fertilization rates, and success decreased with increased fertilizer application (359). A very low cover rate was achieved under fertilizer applications on high elevation coal mine spoil in Alberta (380). This and other legumes perform best with little or no fertilizer.

Soil Reaction

More tolerant of alkaline (pH 8.1) or acid soils than alfalfa (391). Prefers slightly alkaline conditions to somewhat acid (338, 179). Cicer milk vetch is more persistent and higher in production than alfalfa on subirrigated or irrigated, slightly acid to moderately alkaline alluvial soils, including Regosols, where a high water table exists (179). Poor on acid soils; lower limit is 5.0 (713).

Soil Salinity

Salinity tolerance less than sainfoin (Onobrychis viciaefolia) on amended tailings sands and overburden in northern Alberta (404). Salinity tolerance can therefore not be ranked better than modest; fair (713).

Drought

Likely not particularly drought resistant.

Heavy Metals and Hydrocarbons

Growth chamber tests on oil sands with varying oil contents indicate that germination and plant growth was inferior to both alfalfa and sainfoin (404).

Shade

Cicer milk vetch is slightly shade tolerant, and grows well on most mountain rangelands (often forested) of the intermountain states (340).

Grazing or Mowing

A. cicer recovers rapidly after it is cut or grazed on western U.S. ranges (179) but appears to be slower to recover in Canada (138). However, milk vetch plants should not be grazed until firmly established; this usually requires two years, during which time hay crops can be taken (179). Because it propagates vegetatively, as well as by seed, it is not readily killed by rodents (340). Tolerance to grazing is said to be moderate (339).

Susceptibility to Disease and Insect Damage

Noted to be "remarkably free" of diseases and insects in the Pacific Northwest and Great Basin states (179, 138). Prone to damage by pocket gophers (41).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Used for erosion control (175), and apparently a good soil stabilizer (339) due to its rhizomatous habits.

Adaptation to Disturbance

Well adapted to establishment on disturbed sites (339).

Competitive Ability

In Alberta, it is slow to establish and will not compete with rapidly growing plants (391). Alternate-row seeding is recommended for good stands of both grass and the legume when planted together (179). Once established, compatibility is good (339).

Commercial Value

Livestock hay or pasture, wildlife forage, erosion control, and aesthetic use (175, 179). Cultivars characterized by very low herbage yield (139), although in the Pacific Northwest and Great Basin states, production averages are higher (179).

Palatability and Nutritive Value

Low palatability in certain subalpine situations (41), though overall palatability is said to be good (339). Reported not to cause bloat (447, Granite 89), but evidence is conflicting (138). In Alberta, Astragalus spp. in general, provide food for ungulates with high utilization by bighorn sheep, and low utilization by elk, mule deer and moose. Tests with laboratory animals and livestock indicate that cicer milk vetch has no toxic alkaloids (179), and does not accumulate selenium (138).

Seed or Planting Stock Availability

Two cultivars, tested by Agriculture Canada, are "Oxley" (Canada) and "Wyoming Cicer" (Netherlands) (139). "Oxley" is licensed in Canada (138) and seed is readily available from commercial sources. "Lutana" and "Monarch" (639), and "Cicar" (713) are available in the US. Approximately 145 000 seeds/lb (639).

Methods and Ease of Establishment

Seed should be scarified prior to planting (175, 417) to improve germination and establishment (138); slow to establish (175). Noted for weak seedling vigour (41, 417), although the prospects for improving seedling vigour are promising (417). Hardiness rated as moderate. Should be seeded in Canada as a supplement to a grass mixture, with no more than 25% legume content. Successful establishment of cicer milk vetch at high elevations (3 350 m ASL) in Colorado required a very high seeding rate, although initial establishment was greater than other legumes seeded (236). Protect from grazing in the early stages (179). Spring/Fall seeding at a rate of 20 to 25 lbs PLS/ac has been recommended (639); 10 to 15 lbs PLS/ac for eastern US (713).

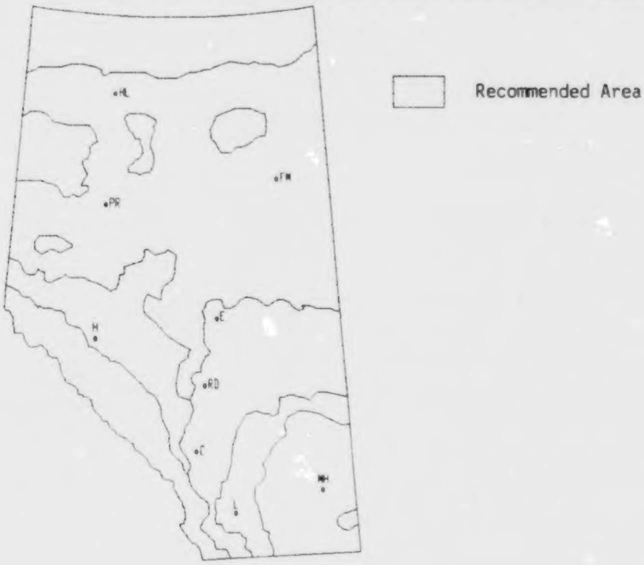
Current Status for Reclamation

A relatively new species to reclamation (175). Much of the experience to date as a plant for revegetation of disturbed lands is experimental. Cicer milk vetch was part of a grass-legume mix used for spring planting on a pipeline river crossing area. First year growth assessments indicated strong establishment comparable to alfalfa (431). Cicer milk vetch produced better grass-legume growth relationships than "Rambler" alfalfa in tests on coarse textured soils in an arid climate (Smoliak 1983). At Fort McMurray it failed in a mix on amended tailings sand (643). Species adaptability trials on high elevation coal mine spoil dumps and exploration disturbances showed rather poor establishment and subsequent growth (380, 371, 723). Strip mine revegetation studies near Grande Cache indicate that cicer milk vetch is poorly suited to that area compared to alfalfa, white clover, alsike clover and birdsfoot trefoil (270, 269). It performed rather poorly, relative to other legumes, in revegetation trials on coal surface mined lands in Montana (117). When seeded on waste rock, overburden and tailings at two metal mines in the southern interior of British Columbia, no growth occurred (143). Establishment of A. cicer on ski slopes in Colorado was rated as "good" to "excellent", at elevations from 2 850 m to 3 420 m ASL (236). After ten growing seasons, cicer milk vetch is noted as the only introduced legume that shows promise in plantings at the Climax mine in Colorado (44). Cicer milk vetch appears suitable for high elevation revegetation, although results in Alberta show uncertain success to date. Local conditions may warrant plot studies to determine establishment, fertilization requirements and growth.

Cicer milk vetch has several desirable characteristics such as its ability to spread by rhizomes, nitrogen fixation ability, and apparent absence of bloat causing substances. It is best adapted to cool, moist sites with medium to coarse textured soils and responds well to irrigation. Adaption to alpine sites requires further testing.

Epilobium spp.

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance					X
pH Acid			X		
Tolerance Base			8.1		
Winter Hardiness	X	X			
Erosion Control			X		
Persistence			X		
Palatability			X		
Browse Tolerance				X	
Moisture Preference	Moist.				
Soil Preference	Clay loam to sandy.				

Epilobium spp.

SPECIES BIOLOGY

Taxonomy

Fireweed; Great Willow-herb; River Beauty (E. latifolium) (214).

Includes E. angustifolium ssp. angustifolium and ssp. circumvagum Mosquin, and Epilobium latifolium ssp. latifolium.

Origin and Range

Native plants, with circumpolar distribution (214).

Growth Habit

Varies from erect stems (E. angustifolium) to 2 m high, with thick creeping roots and woody rootstocks, to stems (few to several) which are decumbent (E. latifolium) and 10 to 60 cm long (Moss 1983). Flowers pink, purple or white, rarely yellow (690).

Nitrogen Fixing - None

Longevity - Perennial herbs (405).

Self Propagation

By seed (194, 257) (germination capacity of 57%), and by rhizomes.

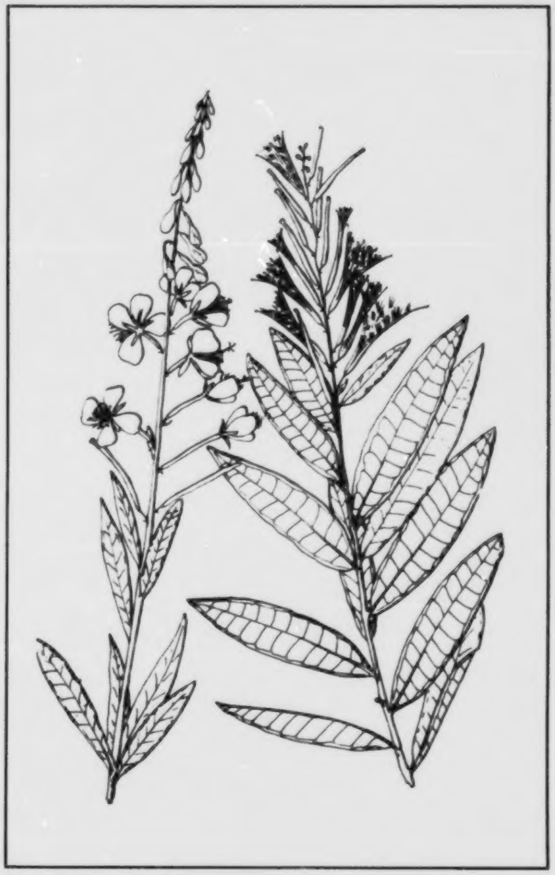
Ecological Setting

For E. angustifolium, open woods, meadows, river bars, aspen thickets, forest clearings, road sides, burned-over forest areas. Optimum slope for revegetation is 9% to 30% (447). Up to 2 900 m ASL elevation (18). For E. latifolium, wet places, especially along mountain streams (690) and scree slopes (214) of subalpine and alpine regions. Part of pioneer stage of plant succession on river alluvium in Alaska (52).

TOLERANCES

Soil Preferences

For revegetation purposes, good growth of E. angustifolium is noted on sandy, loamy, and clayey soil, although it requires moist habitat (447). Optimum soil depth is 33 to 60 cm (447).



Nutrient Requirements

E. angustifolium considered to be a nitrophilous plant associated with increases in soil nutrients following fire (460). This "post fire nutrient flush" is equivalent to a fertilizer application of 13 kg/ha in the first season after fire in a forest-tundra site in the Mackenzie River delta (458).

Soil Reaction

No specific tolerance noted in the literature reviewed, but both species are found on soils with a wide pH range.

Soil Salinity

Generally not found on saline soils.

Drought

E. angustifolium cannot germinate under droughty conditions (314). Otherwise this species is known to tolerate rather dry conditions.

Heavy Metals and Hydrocarbons

Tolerance of E. angustifolium to diesel oil spill indicated (Whitehorse area), where only above-ground portions of the plants have been affected. Where oil penetrated the soil, effects on root systems resulted in death (216).

Shade

As a volunteer plant associated with early successional stages, especially following fire, fireweed is presumably at least somewhat shade intolerant. Natural populations do occur in open, moist forest however.

Grazing or Mowing

Under intense grazing fireweed is seriously depleted (4).

Susceptibility to Disease and Insect Damage

No particular susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Extensive underground rhizomes presumably act to hold soil. Potential of E. angustifolium for erosion control in northwest Colorado is rated as medium (293).

Adaptation to Disturbance

E. angustifolium is noted as a plant that increases following fire (460). It is able to invade exposed peat and mineral soil in the Mackenzie Delta area (194, 459). Fireweed is the most prevalent plant of volunteer growth on fresh and stored peat in the oil sands area (153). Disturbed sites invaded by fireweed in northern environments include roadsides (E. angustifolium) and stream sides (E. latifolium) (459). E. angustifolium is present on reclaimed coal strip mines in southeastern British Columbia (393). Both species are noted to colonize disturbed sites associated with tailings ponds at selected metal mine sites in British Columbia (384). One of the most common species on landfills in Finland (630).

Competitive Ability

A common pioneer after fire on disturbed sites (E. angustifolium) (185), and bare till associated with recessional moraines of Alaskan glaciers (E. latifolium) (104). Noted for invading areas previously disturbed and seeded with erosion control species (494). The need to compete under these conditions is infrequent, but the species tends to diminish as succession proceeds and secondary species appear.

Commercial Value

Flower is considered to be of ornamental value; otherwise, the species is noted as a weed (405). Fireweed (E. angustifolium) is also used as a honey plant (bee pasture). Territorial flower of the Yukon.

Palatability and Nutritive Value

Good forage value for mule deer (447), with moderate use in spring and summer (245). Also grazed by moose. Small mammals such as chipmunks and pika utilize seeds. Chemical composition analyses of selected alpine tundra plants in Alberta indicated that crude protein, calcium, phosphorus, and ash contents of E. angustifolium generally averaged higher than those of selected grasses. Average cellulose content and digestibility coefficients were lower than in the grasses (225).

Seed or Planting Stock Availability

E. angustifolium (marketed as Fireweed) and E. latifolium (marketed as Dwarf Fireweed) are both commercially available from seed suppliers, but only in relatively small quantities. They are inexpensive relative to other native forbs, though expensive compared to grasses and legumes. Plants flower in summer/fall (639). Approximately 8 500 000 seeds/lb (639).

Methods and Ease of Establishment

Trial plots on disturbed soil conditions in the N.W.T. indicate that cereal nurse crops do not enhance the rate of cover of E. angustifolium; this actually resulted in a decrease in cover (195). Indoor germination time of seed is 10 to 15 days at 16 to 20°C; outdoor germination time is 15 to 30 days (293). The exceedingly small seeds cause handling problems (P. Ziemkiewicz, pers.comm.). A seeding rate of 0.25 lbs PLS/ac is recommended (639).

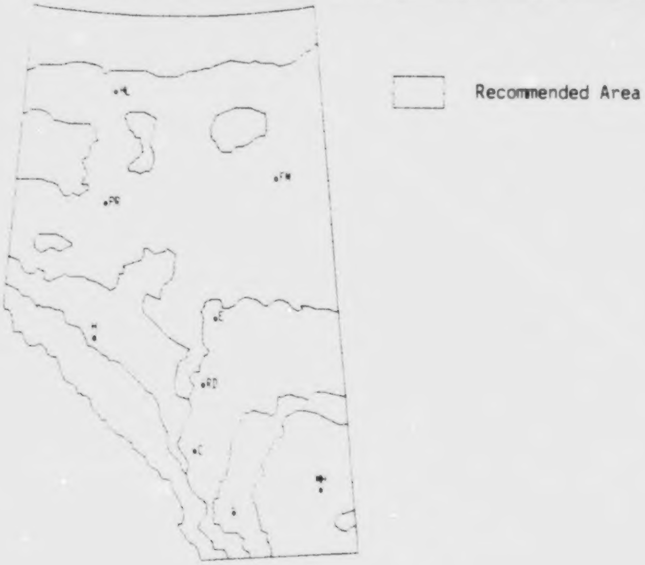
Current Status for Reclamation

E. angustifolium was under study (144) for application in revegetation of mined-land in Alberta. Revegetation trials on oil sand tailings indicated that E. angustifolium did not establish when seeded with other grass and herb mixtures, and on various surface treatments. However, where surface soil and organic matter was mixed into tailings sands, E. angustifolium was among the species established (257). Experimentation with several native species on winter roads in the Northwest Territories indicated that E. angustifolium was the most successful species of the native mix used (195). Fireweed has been introduced on rock waste at a Quebec iron mine; no additional information is available (316). In eastern ponderosa forests of Montana and Wyoming, this fireweed is considered to have high revegetation potential and low establishment requirements for strip mine reclamation (447).

General observations of fireweed naturally colonizing disturbed sites associated with mining, and road and pipeline development indicate its potential for revegetation of reclaimed lands, particularly in the early stages of reclamation (384, 393).

Hedysarum spp.

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid					
pH Tolerance Base		X			
Winter Hardiness			X		
Erosion Control				X	
Persistence			X		
Palatability			X		
Browse Tolerance				X	
Moisture Preference	Dry to moist.				
Soil Preference	Silt loam to sandy loam.				

Hedysarum spp.

SPECIES BIOLOGY

Taxonomy

Alpine Hedysarum (Hedysarum alpinum); Northern Hedysarum, Mackenzie Hedysarum, Northern Sweetvetch (H. boreale); Sulphur Hedysarum; Yellow Hedysarum (H. sulphurescens) (506, 78).

Hedysarum alpinum L. var. americanum (Michx.), H. boreale Nutt. var. boreale and var. mackenzii (Rich.) C.L. Hutchc.; also H. mackenzii Rich.; H. sulphurescens Rydb.

Origin and Range

Native. Circumpolar distribution (214). Range throughout western North America. In Alberta, primarily along the Rocky Mountains and adjacent boreal and aspen parkland forests (690).

Growth Habit

Forbs with erect or ascending (several to numerous) stems, 10 to 70 cm high (690). Noted for bunch growth habit and late fall growth (436); however, also noted for good spring growth and limited forage production in fall (665). Flowers pink, purple, yellow or whitish (690).

Nitrogen Fixing

Hedysarum supports nitrogen fixing bacteria enabling it to grow in relatively infertile soil materials. It will grow adequately without rhizobia (J. Weijer, pers.comm.).

Longevity

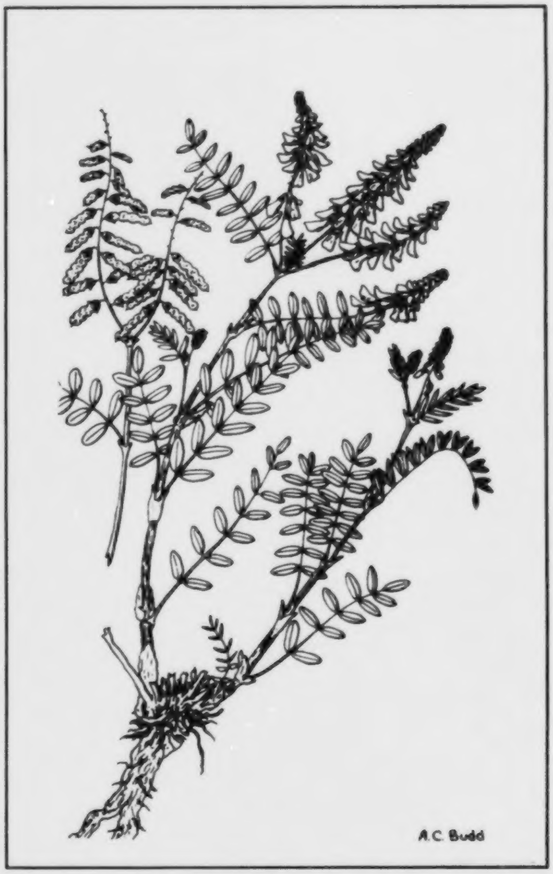
Perennial forbs (405). Alpine hedysarum and Mackenzie hedysarum have demonstrated good winter hardiness (239).

Self Propagation

Seeds from simple dry dehiscent fruit (214).

Ecological Setting

Generally abundant through the foothills, the Cypress Hills, the prairies, and in open woods of the Rocky Mountains (690). H. boreale appears on rocky slopes, dry hillsides, and river bars to about 1 200 m ASL (214). Distribution of these three species extends from alpine tundra (H. boreale) to boreal and sub-boreal spruce forest (214, 459). H. alpinum noted as part of the tall shrub-herb community associated with floodplains and lake shores in Mackenzie Delta (97).



TOLERANCES

Soil Preferences

Moist to dry sandy loam to silt loam soils. Will grow on poorly developed colluvial materials as well.

Nutrient Requirements

Expected to do well on sites low in nutrients.

Soil Reaction

Noted for alkalinity tolerance (436).

Soil Salinity

Moderately tolerant of saline soils.

Drought - Moderately drought tolerant.

Heavy Metals and Hydrocarbons

No specific tolerances noted from the literature reviewed.

Shade

Will grow in partial shade.

Grazing or Mowing

Most native legumes regrow poorly after cutting compared to cultivated legumes (239). Hedysarum spp. are characterized as "decreaser" range plants, i.e., relatively sensitive to grazing pressure. Overuse of these species usually indicates an overgrazed range.

Susceptibility to Disease and Insect Damage

H. boreale regarded as resistant to northern diseases (436).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

These plants have woody taproots (505). Nitrogen fixing capability of Hedysarum increases soil nitrogen levels.

Adaptation to Disturbance

In general, native legumes are pioneer species which can invade and grow in barren areas; nitrogen fixation permits growth in relatively infertile soil materials (239).

Competitive Ability

H. boreale rated for "good biocompetitive ability" (436), but observed to have very slow first year growth (D. Walker, pers.comm.).

Commercial Value

Regarded as desirable plants to native ranges (for cattle). Flowers have ornamental value (214). Also important for wildlife range, and for nitrogen contributions.

Palatability and Nutritive Value

Reports on the nutritive value of Hedysarum spp. vary considerably. H. boreale reported to be poisonous (214) and not toxic (665). Crude protein in 11 western US H. boreale ecotypes varied from 12.9% to 16.6% at first harvest and 5.4% to 10.3% for the second harvest near Logan, Utah (alfalfa control values were 17.6% and 10.7% respectively) (665). Roots and stems of H. alpinum are edible; the plant is eaten by bears and mice (214). Hedysarum spp. are noted as range plants useful for sheep, cattle, and grazing ungulates (elk, bighorn sheep).

Seed or Planting Stock Availability

No source of commercial seed has been located. Flowers in spring with approximately 33 000 seeds/lb (639). Seed weight varied between 0.137 g/25 seeds to 0.243 g/25 seeds for 11 western US ecotypes (665).

Methods and Ease of Establishment

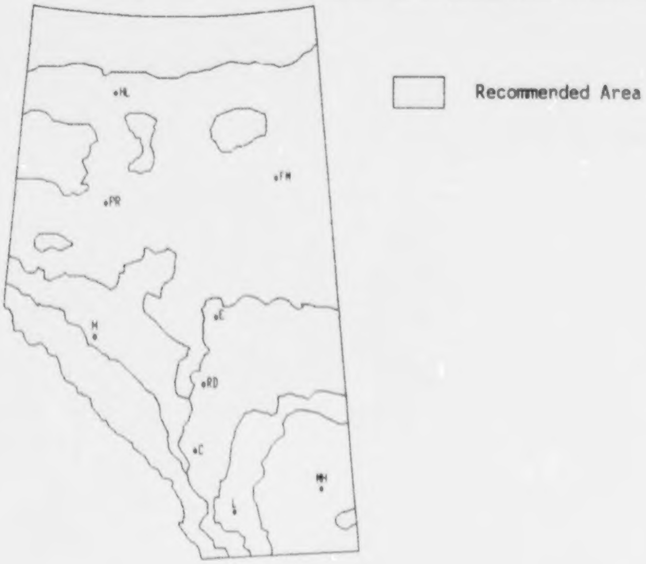
Seed collection is relatively easy when plants are abundant because of pod formation and large seeds. Hedysarum produces plants in fair abundance. Germination of seeds may be enhanced through scarification of seed coat or immersion in concentrated sulphuric acid (239). Greenhouse tests of H. alpinum seeds collected in the field indicated that Hedysarum has a germination rate of about 50% which is about 10% better than Oxytropis spp. (268). A seeding rate of 15 lbs PLS/ac has been recommended (639).

Current Status for Reclamation

The status of Hedysarum spp. for revegetation of disturbed lands is still one of experimentation. Attractive features include winter hardiness, wildlife range value, nitrogen fixing ability, status as native species, and aesthetic considerations. Revegetation research at Grande Cache included seed collection and seeding of H. alpinum, although little or no growth occurred (268). Revegetation along pipeline rights-of-way in northeastern B.C. indicated that survival and germination of H. alpinum seed stock (ecotype derived from native seed collections) varied from 3% on unstable and steep slopes with sandy soil to 10% on slopes with clay loam soils and more stable conditions (431). Revegetation tests of various native legumes in Alaska indicate that Hedysarum may be adapted to commercial utilization (239). The group warrants further investigation. Ecotypic variability within western US H. boreale indicates a good chance of finding adaptable plants and breeding these for specific uses (665).

Lathyrus ochroleucus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING			
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid				X	
pH Tolerance Base				X	
Winter Hardiness		X			
Erosion Control		X	X		
Persistence			X		
Palatability			X		
Browse Tolerance				X	
Moisture Preference	Moist.				
Soil Preference	Loam to sandy loam.				

Lathyrus ochroleucus Hook.

SPECIES BIOLOGY

Taxonomy - Vetchling, Pea Vine

Origin and Range

Native. Ranging from Mackenzie District, Northwest Territories to Quebec, south to northeastern Washington, Idaho, Montana and the north central states to central Pennsylvania. General in the eastern half of British Columbia. In Alberta and most of southern Canada in forested areas (214, 199, 690).

Growth Habit

Herb with horizontal rootstocks and slender climbing stems (long and twining), up to about 1 m tall; leaves alternate, pinnate, usually tendril-bearing at the tip; flowers in axillary racemes (312). Yellowish white flowers (690).

Nitrogen Fixing

Fixes atmospheric nitrogen.

Longevity

Perennial (withering) herb (312, 405).

Self Propagation

Simple dry dehiscent fruit (405), with several seeds contained in a linear pod (317).

Ecological Setting

Open woods and northern meadows (690) from boreal white and black spruce forests (405) to montane lodgepole pine - Douglas fir forests and the aspen parkland.

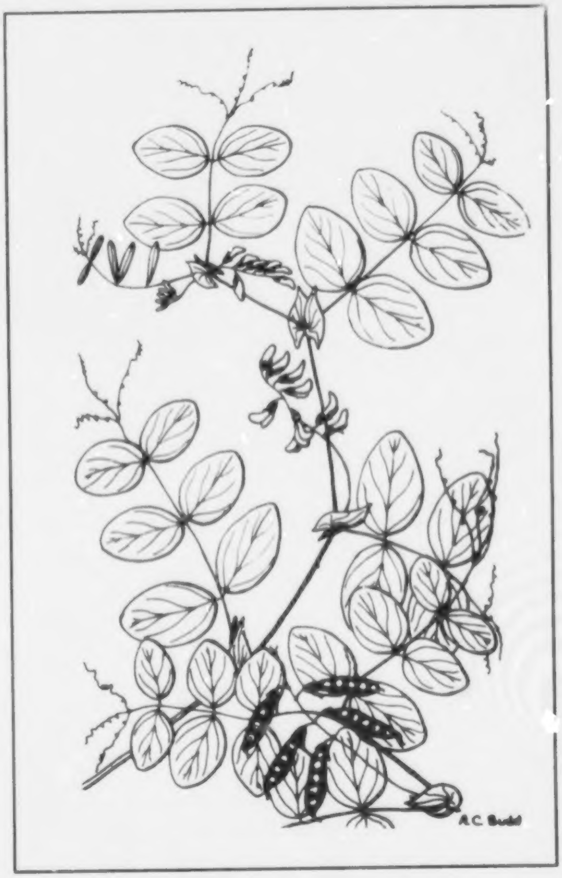
TOLERANCES

Soil Preferences

Prefers loam to sandy loam soils. Generally found on Podzols, Brunisols and Luvisols. Distribution indicates that the species favors moist soil conditions.

Nutrient Requirements

Can withstand low nitrogen soils. Requires fair levels of other nutrients.



Soil Reaction

Appears to be generally restricted to near neutral pH ranges.

Soil Salinity

Can be expected to tolerate mild soil salinity.

Drought

Moderately intolerant of droughty conditions.

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Presumably moderately shade tolerant, because of its association with open woods.

Grazing or Mowing

Lathyrus spp. are regarded as "decreaser" species, sensitive to continued overuse on cattle ranges.

Susceptibility to Disease and Insect Damage

Resistance to disease and insects of related Lathyrus spp. on Utah ranges is rated from "medium" to "very good" (339).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Soil stabilizing ability associated with growth of related Lathyrus spp. on Utah ranges, varies from medium to very good (339).

Adaptation of Disturbance

As a "decreaser" plant on Alberta ranges, Lathyrus spp. appear not to withstand physical disruption particularly well. The species is, however, often noted colonizing moist roadsides and other disturbances.

Competitive Ability

Overuse of this species is associated with conditions favorable for establishment of other species more tolerant to grazing or more unpalatable for grazers. In general, Lathyrus spp. are rated medium to poor for initial establishment on Utah ranges (339), and noted for "good" persistence. Though not highly competitive, the species are not easily eliminated from established forests and meadows unless heavily grazed.

Commercial Value

This species is a native nitrogen fixing legume, suitable for reclamation, including moderate wildlife use.

Palatability and Nutritive Value

Utilized to a moderate extent by wildlife. Presumed to provide moderately good nutrition.

Seed or Planting Stock Availability

Native seed production and handling of Lathyrus spp. in Utah is very good. Ease of planting of related species varies from medium to very good (339).

Methods and Ease of Establishment

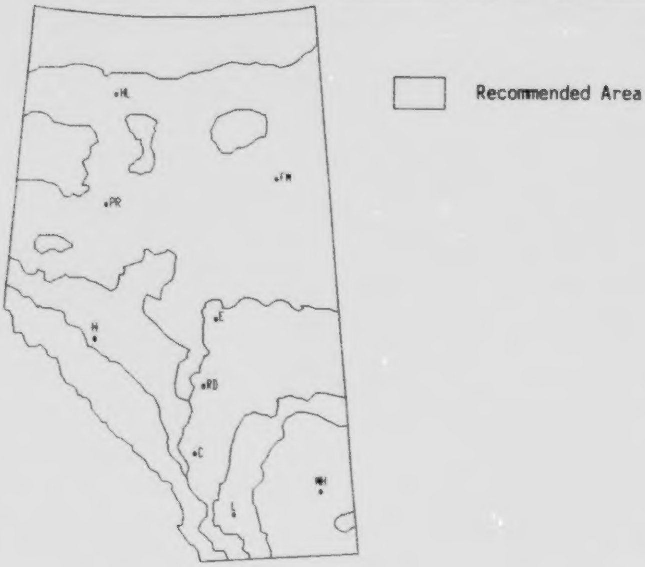
Lack of success in establishing L. ochroleucus on pipeline rights-of-way in northeastern British Columbia may indicate a lengthy dormancy period prior to germination of seeds (431). Ease of transplanting of related Lathyrus spp. on Utah ranges is generally regarded as good (339).

Current Status for Reclamation

Information reviewed indicates that the usefulness of Lathyrus ochroleucus for reclamation remains to be established. Because of some characteristics, including nitrogen fixing ability and adaptability to a wide range of ecological patterns, the plant warrants further study, better defining revegetation suitability. Related species demonstrate usefulness in reestablishment of native range.

__Lotus__ __corniculatus__

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid		4.5			
pH Tolerance Base			X		
Winter Hardiness			X	X	
Erosion Control			X		
Persistence		X			
Palatability	X	X			
Browse Tolerance			X	X	
Moisture Preference	Dry to moist, some cultivars tolerant of flooding.				
Soil Preference	Medium to fine textured, moderately well to poorly drained.				

Lotus corniculatus L.

SPECIES BIOLOGY

Taxonomy - Birdsfoot Trefoil.

Origin and Range

Native to Europe, from the Mediterranean to Scandinavia. It was probably introduced to North America accidentally around the turn of the present century (138).

Growth Habit

The distinct foliage and delicate yellow flowers make this an aesthetically pleasing plant (41). Plants are similar to alfalfa (Medicago spp.) in growth habit, and reach heights of about 30 to 75 cm. Stems are slender and branched (138). It spreads by underground rhizomes (446). It has a well developed taproot system with numerous lateral branches (37). Flowers yellow, often red-tinged (690).

Nitrogen Fixing

Birdsfoot trefoil fixes atmospheric nitrogen. Nodulated plants have been observed on soils with pH as low as 4.5 (444). Stand establishment may, however, be limited by poor nodulation on some spoils with pH below 5.0 (40).

Longevity

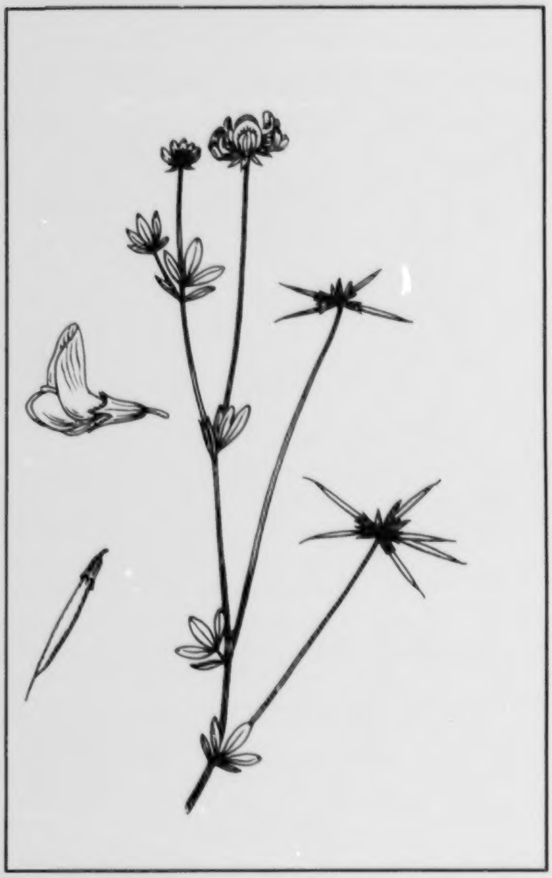
Relatively long-lived cool season (713) perennial (138). Birdsfoot trefoil was found to give an excellent initial stand but thinned out rapidly after the second or third growing season (228). Some cultivars are susceptible to winterkilling; "Carroll" is more winter hardy than other licensed cultivars (138), although "Cree" is best (D. Walker, pers.comm.).

Self Propagation

Propagation is predominantly by seed. The cultivar "Leo" requires long day length to produce seed. It becomes dormant early in the fall (6).

Ecological Setting

Birdsfoot trefoil may persist for a few years in the upper subalpine (Colorado) (41). However, it was reported to do poorly at 2 570 m ASL (417), and at 3 350 m ASL (44) in Colorado. Does best with 45 to 114 cm precipitation (713).



TOLERANCES

Soil Preferences

Birdsfoot trefoil prefers moist sites and may require irrigation in drier reclamation areas (426). It will grow on poorly drained through to droughty soils 937). "Empire" and "Leo" are varieties tolerant of wet land and flooding. "Carroll" is also tolerant of imperfectly drained soils (6). "Maitland" is less tolerant of saturated soils (138).

Nutrient Requirements

Birdsfoot trefoil has low nutrient requirements (466). Legumes are usually sensitive to low plant-available potassium and phosphorus, conditions which are sometimes present on coarse textured spoils.

Soil Reaction

In field trials, birdsfoot trefoil grew on spoils with pH values as low as 4.5 (278). In general, grasses will survive on soils in the pH range 4.5 to 5.5 but this is too acidic for most legumes (44). Birdsfoot trefoil has been established on coal spoils of pH 5.0 to 5.5 (228). It has been recommended for revegetating spoil with pH values of at least 4.5 (713) to 5.0 (123). Some genotypes can apparently withstand considerable acidity. In a laboratory test, liming acid spoils with dolomite inhibited the establishment of birdsfoot trefoil compared to spoils limed with hydrated lime or agricultural lime (411).

Soil Salinity

Birdsfoot trefoil had satisfactory growth on tailings with an electrical conductivity of 8 mS/cm (163).

Drought

Legumes in general do poorly on coarse textured droughty soils (44). Birdsfoot trefoil, however, appears to grow satisfactorily on moderately droughty soils (37).

Heavy Metals and Hydrocarbons

Birdsfoot trefoil exhibited no toxicity symptoms when grown on three spoils containing 50 ppm water-soluble manganese (40). No other tolerances have been noted.

Shade

Generally intolerant of excessive shade.

Grazing or Mowing

Its low growth form allows grazing or mowing with minimal reduction in plant vigour. Some cultivars are sensitive to overgrazing or cutting, and are slow to recover. Most recover quickly (138). Persistent.

Susceptibility to Disease and Insect Damage

May be attacked by Sclerotinia trifoliorum Erikss. and Rhizoctonia spp. which are not serious pests in Canada (138).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Birdsfoot trefoil has a well developed taproot system with numerous lateral branches. It will root to a depth of 1 m or more in good soil conditions (37).

Adaptation to Disturbance

Does well on disturbed sites, including agricultural lands.

Competitive Ability

Fairly aggressive initially, but dies back as stands become established.

Commercial Value

Birdsfoot trefoil is used for forage and in stabilization plantings (426). It is a perennial forage legume used for pasture, hay, and silage in the northwest and north-central US. (37).

Palatability and Nutritive Value

Birdsfoot trefoil is a highly palatable (427), non-bloat causing species (41, 138). Herbage yield of several cultivars including "Diana", "Lot", "Maitland", "Mansfield" and "Tara" have been rated as very good to excellent (139). Birdsfoot trefoil may contain hydrocyanic acid (221).

Seed or Planting Stock Availability

Seed readily available from most dealers. Licensed varieties grown in Canada include "Empire", "Viking", "Leo", "Maitland", "Mirabel", "Carroll" and "Cree" (6, 138). "Dawn", "Fergus", "Cascade", "Granger", "Tana", "Douglas", "Mansfield" and "Norcen" available in the US (639, 713). Approximately 418 000 seeds/lb (639).

Methods and Ease of Establishment

Typical purity/germination is 96/90% (132). Birdsfoot trefoil generally has weak seedling establishment and vigour, but has excellent persistence, although growth is slow (6). A seeding rate of 10 to 15 lbs PLS/ac has been recommended for the Eastern US (713).

Current Status for Reclamation

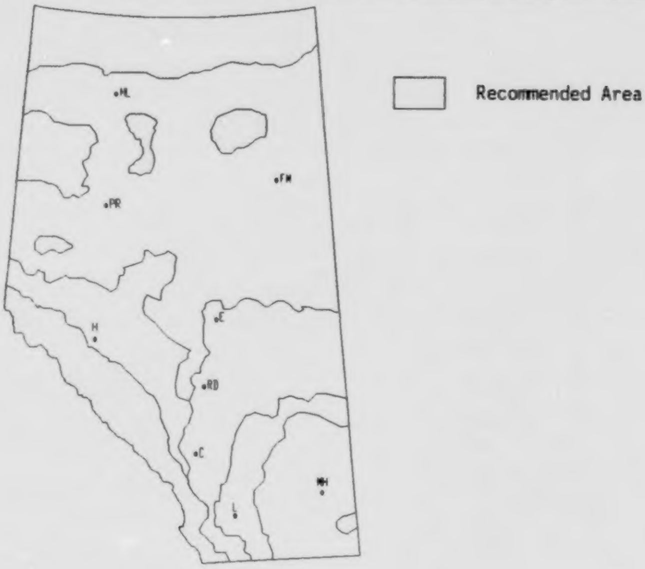
Birdsfoot trefoil is a fairly widely used pasture species, though it is also utilized for silage, hay and erosion control in Alberta. It has been successfully established on unfertilized coal mine reject material near Grande Cache, Alberta. Plants were vigourous and nodules were present (271). Birdsfoot trefoil was, however, the poorest of eleven legumes tested at Norman Wells, N.W.T. (195). It also failed in the subalpine in first year testing at Tent Mountain (723). "Empire" birdsfoot trefoil was persistent after four growing seasons on limed, acid uranium mine tailings at Elliot Lake, Ontario. Yield and nodule formation was poor, however (318). It also produced well on an ash lagoon after three years

(696). It showed promise for revegetation in Montana and on subalpine sites in southeastern Idaho, northeastern Utah and western Wyoming and at 1 900 m (subalpine) in north central Washington (209). Birdsfoot trefoil was poor in vigour and ground cover density after four growing seasons compared to alfalfa on mine tailings in northwestern Colorado (1 850 to 2 450 m) (39). Birdsfoot trefoil has been recommended for revegetation of disturbed sites in northwestern Colorado that were cold and moist, received more than 50 cm of precipitation per year and were above 2 670 m ASL elevation. Soils were mostly shallow and low in fertility (427). It is used successfully in Britain for mine reclamation (123). The cultivar "Leo" is regarded as suitable for use in Alberta and the Peace River region where a non-bloating legume is required. This cultivar has good seedling vigour and responds to high fertility (6).

Birdsfoot trefoil is an attractive legume with a low spreading growth habit which provides little competition to planted trees. Some varieties are moderately drought tolerant while others can withstand poorly drained soils. It fixes atmospheric nitrogen and its ability to grow well on acid spoils has led to its widespread use for revegetation on acid coal mine spoils in Europe and the northwestern United States.

Lupinus argenteus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No_X_

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid					
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence			X		
Palatability			X	X	
Browse Tolerance			X	X	
Moisture Preference	Moist to dry.				
Soil Preference	Clay loam to sandy loam.				

Lupinus argenteus Pursh

SPECIES BIOLOGY

Taxonomy - Perennial Lupine; Silvery Lupine

A taxonomically difficult genus (Moss 1983). Hybridizations between L. argenteus and L. caudatus complexes can explain many taxonomic variations (657).

Origin and Range

Native. Common in the Alberta foothills, Cypress Hills and submontane prairie in southwestern Alberta (78). Southern British Columbia to Saskatchewan south to northeastern California; Arizona, New Mexico and South Dakota (690).

Growth Habit

A shrubby many-branched herb, 50 to 100 cm tall (78, 690). It is a highly variable species with growth habit varying from stemmy to bush (236). Flowers light violet, occasionally whitish (690).

Nitrogen Fixing

Estimated seasonal fixation rate of 0.14 mg N_2/gm of nodules for silvery lupine growing in lodgepole pine forests in southeastern Wyoming. Maximum N fixing rate was estimated at 0.1 g m^{-2} yr^{-1} in these dry, infertile stands. Silvery lupine is capable of fixing nitrogen on high altitude disturbed sites. It fixes nitrogen at rates 5 to 15 times greater than other legumes growing at high altitudes in Utah and Montana. The large size of nodules suggested that they may function over more than one growing season. Nodule mass varies from 0.05 to 2.0 g dry wt. per plant (666).

Longevity

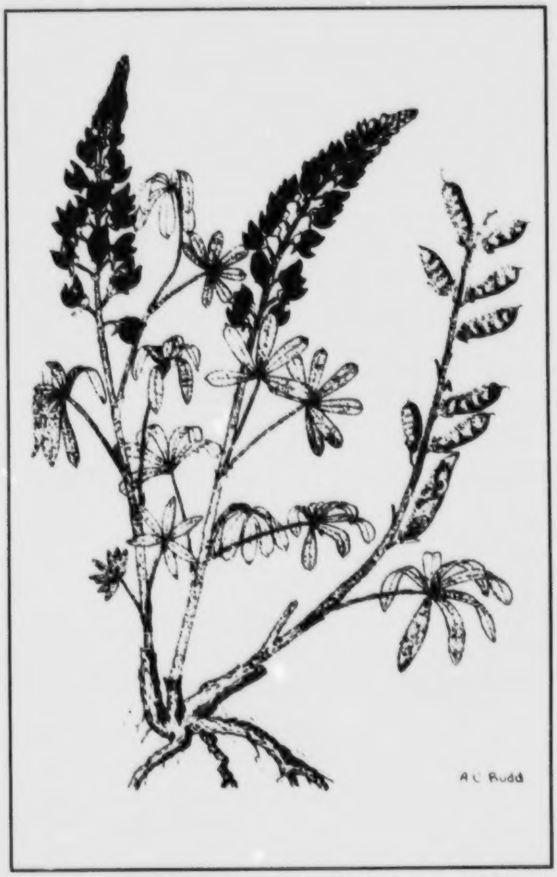
Hardy, perennial herb (312, 293). Dies back in fall.

Self Propagation

By seed (690), spreads slowly to form colonies.

Ecological Setting

Silvery lupine is a common species of the prairie and the submontane prairie of southwestern Alberta (78). Grasslands and roadsides, prairie slopes and ridges (690). Silvery lupine is found on a wide range of habitats from forest understorey, road banks and sagebrush communities to sand dunes (236). One of the most widespread lupines in high altitude areas in western North America (666). It has been reported at 1 450 m ASL in northeastern British Columbia (70). It is often found on alpine sites in association with Dryas octopetala or Dryas integrifolia (209).



TOLERANCES

Soil Preferences

Silvery lupine has been reported on a variety of soil textures from gravelly clay loam to clay loam and on shallow soils (70). Growth is reported to be good on sandy and loam soil and fair on clayey soil. Optimum soil depth reported as 0.3 to 0.7 m and the optimum slope is 9% to 30% (446). Silvery lupine is reported to do best on moist to dry habitats (446). Prefers mesic habitats in southern Alberta. Has been described as strict calcifuge found only on non-carbonate soils (682).

Nutrient Requirements

Lupines in general do well on low nutrient sites

(436). Requires high levels of available phosphate and to a lesser extent high available iron (682). Reported to grow well on high altitude sites, one with high levels of phosphate, potassium and magnesium and the other with high levels of magnesium and calcium (666). Actively mycorrhizal.

Soil Reaction

Found on moderately acid soils (636). Reported on two sites with soil pH values measured at between 4.5 and 5.0, and 5.5 to 7.0 (666). Found only on non-carbonate soils (682).

Soil Salinity

Not particularly tolerant of saline soils.

Drought - Relatively drought tolerant (436).

Heavy Metals and Hydrocarbons

Grew well on a site with excessively high levels of iron and copper (666).

Shade

Does best on open sites. Most commonly found in sun (677).

Grazing or Mowing

Not usually subjected to heavy grazing as it is relatively unpalatable.

Susceptibility to Disease and Insect Damage

Lupines found in northern areas are resistant to northern diseases (436). The related species L. sericeus is susceptible to stem rot (383). Susceptible to fungus disease Erysiphe polygoni DC ex Merat. Silvery lupine is alkalloid containing, therefore it is less likely to be damaged by herbivory (677).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Has long slender taproot with numerous lateral roots which could aid in erosion control. Potential for significant nitrogen input via N-fixation, particularly in some lodgepole pine stands where lupine density may exceed 10 000 stems/ha (632).

Adaption to Disturbance

Active colonizer of high altitude, disturbed sites (666). Lupinus spp. volunteered along the margins of disturbed mine site in the subalpine near Grande Cache, Alberta. It also became established from seed introduced in the soil topdressed on the disturbed area (271, 679). Silvery lupine has been reported as a pioneer on disturbed drill pad sites in the northeast coal block, British Columbia (70).

Competitive Ability

Not particularly aggressive.

Commercial Value

Erosion control, wildlife cover (187).

Palatability and Nutritive Value

Silvery lupine is reported to have low palatability (427). Has been found to contain an alkaloid (anagyrine) in concentrations sufficient to cause crooked calf disease in in-calf cows (624). Alkaloid found mostly in seeds and pods, has caused sheep losses (226). Silvery lupine found to exhibit considerable variability in alkaloid content. It may be possible to develop low alkaloid strains (623). Silvery lupine is reported to be a source of browse for Rocky Mountain mule deer (245). It has been reported to provide good cover for small mammals and game birds and poor cover for mule deer. Forage value has been rated as good for mule deer, small mammals and game birds (446).

Seed or Planting Stock Availability

No source of native seed has been identified. Several other related species are available in the US, including L. alpestris (mountain lupine) and L. caudatus (tailcup lupine) (639).

Methods and Ease of Establishment

The pods of silvery lupine are about 2 cm long and contain 4 to 6 seeds. These can be collected while they are green and then air dried to open the pods. When dried, lupine seeds can be stored for long periods of time. However, they develop a hard seedcoat with storage. Approximately 70 seeds/g. Fresh seed can be sown, or stored seeds can be treated with boiling water and soaked 12 to 24 hours before sowing. Germination times are 10 to 20 days indoors (18 to 24°C) and 15 to 30 days outdoors (293, 39, 419). Late fall seeding of legumes has been recommended in high altitude regions since in some cases they will germinate early enough the following spring to produce enough growth for over-wintering root reserves (236). Early fall seeding in some cases results in limited growth. Innoculation of *Lupinus* sp. with the microflora of the rhizosphere (*Azotobacter*) produced greater crop yields than fertilizing with NPK on coal spoil banks (209).

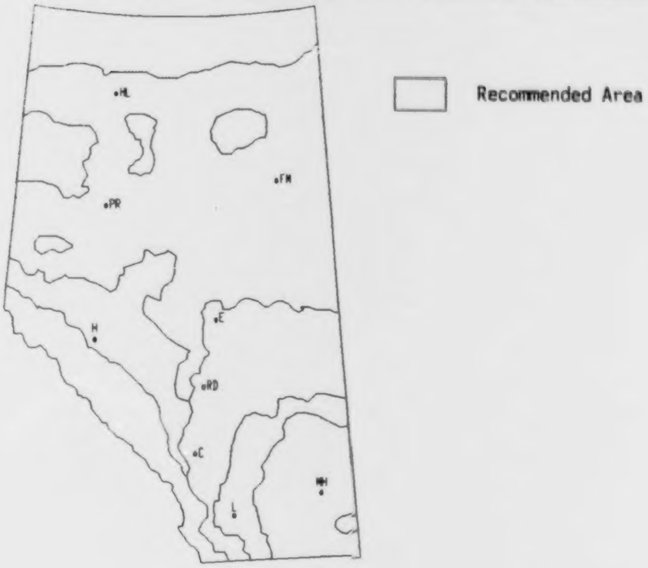
Current Status for Reclamation

Silvery lupine is a variable species found in many habitats to the subalpine in Alberta. It has been recommended as a species suitable for revegetation of critical sites in northwestern Colorado. The suggested zones for planting this species are moist and cold, and at elevations above 2 700 m ASL where soils are shallow and there are many slides and rock outcrops (427). Transplants of silvery lupine were successful on a disturbed minesite in the alpine of southern Montana (76). Silvery lupine has been rated as poor for revegetation of processed oil shale in Colorado (396). Various populations of silvery lupine are being evaluated for revegetation potential (236).

Silvery lupine is a particularly promising species for revegetation of disturbed areas at high altitudes. Major assets are its ability to grow well on eroded or rocky soils, its colonizing characteristics and its ability to fix atmospheric nitrogen. Although it may be poisonous to livestock, it is browsed by game to some extent and there is potential to develop low alkaloid strains. Further research is needed into seed production and requirements for establishment.

Medicago spp.

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance			X		
pH Tolerance Acid			5.5		
pH Tolerance Base		X	X		
Winter Hardiness		X	X		
Erosion Control			X		
Persistence			X	X	
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Moist to dry.				
Soil Preference	Deep loam - tolerates wide textural range, well drained.				

Medicago spp.

SPECIES BIOLOGY

Taxonomy

Yellow Lucerne; Sickly Medick; Black Medick; Alfalfa; Lucerne.

M. falcata L., M. sativa L. and M. lupulina L.

Origin and Range

All species have been introduced to North America. Originated in Asia Minor (138). Widespread throughout North America and Europe. Recently, other varieties which originate from crosses of M. sativa and M. falcata have been developed. These varieties are often grouped under the species name M. media Pers. Some examples are the cultivars "Ladak", "Beaver", and "Rambler" (191). These varieties provide adaptability for a wide range of climatic regions in Canada.

Growth Habit

Herbs with slender stems which are elongated and erect (M. falcata and M. sativa) (up to 1 m long) or prostrate and wide-spreading (M. lupulina) (20 to 80 cm long) (312). Much branched. Deep rooted (405). Root systems of various varieties include tap root, branch root, rhizomatous root, and creeping root (191). Heights of cultivars tested in Canada range from 48 to 77 cm (139). Flowers yellow or bluish purple, occasionally whitish (690).

Nitrogen Fixing - Fixes atmospheric nitrogen.

Longevity

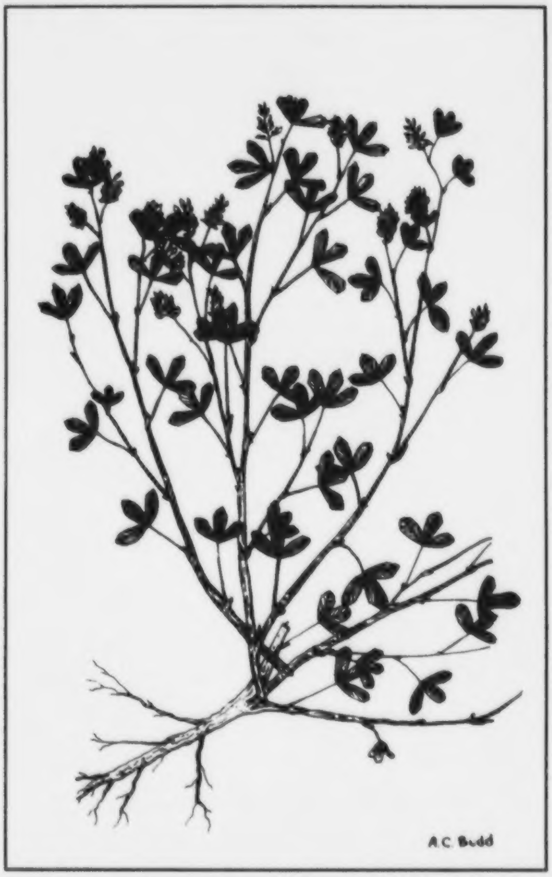
Annual (M. lupulina), or perennial (M. falcata; M. sativa) herbs (312). M. sativa is a cool season species (713). Subject to winterkill, primarily due to unfavorable weather conditions (191).

Self Propagation

Seeds. Creeping rooted plants also develop horizontal rootstalks from which shoots and independent plants arise (191).

Ecological Setting

Common in fields, waste places, and along roadsides (312). It is adapted to a wider range of climate and soil than any other legume (79). Can be grown in all areas of Alberta (39). In Wyoming, M. sativa found at elevations between 1 260 m and 2 640 m ASL (19). M. sativa is considered poorly adapted to the upper subalpine (41), although M. sativa showed good to excellent growth at high elevation sites in Colorado between 3 000 m and 3 300 m ASL (rated as difficult to establish here) (44). Alfalfa had the best persistence of legumes tested on various mountain meadows in Colorado (359). In southeastern British Columbia, alfalfa grew satisfactorily on disturbed subalpine sites to 2 190 m ASL (162). Fair performance and adaptation on north and east facing slopes, and poor growth on south and west facing slopes in Montana (422). Alfalfa requires a mean annual precipitation of 40 cm (179); 38 to 50 cm (713). In Arizona, Colorado, and Montana it grows well with less than 35 cm mean annual precipitation, in the absence of irrigation (175).



TOLERANCES

Soil Preferences

Alfalfa requires deep, well drained soils (179). In Alberta, alfalfa is best adapted to deep loam soils with porous subsoils; good drainage is essential

(391). It has great value as a soil improving crop (391), particularly due to nitrogen fixing ability. M. falcata is suited to sandy or gravelly soil. In northwest Colorado, M. sativa is rated as providing fair growth on sandy and clayey soil (446). M. falcata outperformed M. sativa on clay loam soils (with moderate to good moisture content) at a pipeline revegetation project in northeast British Columbia (431).

Nutrient Requirements

As a nitrogen fixing plant, alfalfa needs little or no additional nitrogen from fertilization. However, legumes such as alfalfa require relatively large amounts of phosphorus, potassium, and sulphur and will respond to the addition of fertilizer when these nutrients are not adequately supplied by the soil (391). Comparative growth tests on coal mine waste near Grande Cache, Alberta indicate that growth was superior in plots not fertilized since initial fertilization, but they appear more vigourous in those plots where maintenance applications of fertilizer have been made (269). Similar results were noted after 14 years in mixed seedings on amended tailings sand (645). Use of leonardite (low energy coal), as a soil amendment, improved growth of alfalfa on mine spoil and soil mixtures in greenhouse tests; results suggested that greater availability of native Zn and Mn in the presence of leonardite resulted in improved growth (367).

Soil Reaction

Alfalfa is particularly well adapted to soils with a high lime content or soils that are nearly neutral (191). It is relatively tolerant of alkaline soils, but sensitive to acidic conditions (391). It is suited to a pH range of 5.5 to 7.0 (362); minimum of 6.0 (713). In Kentucky, alfalfa was recommended for seed mixtures on alkaline and calcareous coal spoil (pH above 7.3); also for moderately acid to alkaline spoil (pH 6.2 to 7.3) (423).

Soil Salinity

Alfalfa has medium tolerance to salt (4 to 8 mS/cm) relative to other plants (247), with poor tolerance at the germination stage, but good tolerance at the established stage (468). Alfalfa is indicated to have lower salinity tolerance than sainfoin on artificially salinized tailings sand and overburden (404). In Montana, it is indicated to show fair performance and adaptation to saline-alkali sites, comparable to sweetclover (Melilotus spp.) and cicer milk vetch (Astragalus cicer).

Drought

Selected varieties are noted for drought resistance ("Rambler") (191). In Alberta, it is considered highly drought resistant, but becomes dormant during drought periods and resumes growth only when moisture conditions become favorable (391).

Heavy Metals and Hydrocarbons

Alfalfa has a relatively low tolerance to oil (282, 113). Alfalfa tested at Wabamun, Alberta indicated that plants grown on various surface cappings over ash showed boron levels within the normal agricultural range (305). Biomass production on ash was best of any legume after three years (696). Alfalfa (M. sativa) was successfully grown on asbestos tailings, with high pH and relatively high concentration of Ni and Cr (310). Alfalfa and other seeded species provided satisfactory growth on gypsum waste, containing minor amounts of fluoride (163). Alfalfa produced high yields after four years of growth on uranium tailings in Ontario (better than other legumes), although rapid decline in health and vigour apparently occurs after this period. The tailings were characterized by high concentrations of heavy metals, low pH, very little N or P, low CEC (318). Comparative growth chamber tests of alfalfa, cicer milk vetch, and sainfoin on oil sands materials high in bitumen indicated that all legumes were successfully grown although covers provided were not considered adequate (404).

Shade

Associated with shade free areas (340).

Grazing or Mowing

Flemish types developed in Europe recover more rapidly after cutting and yield more at second and third cuttings than Standard types developed in North America, although Flemish types are more susceptible to diseases. Alfalfa withstands continuous grazing quite well, but it thins out rapidly when closely grazed (191). Because hay strains of alfalfa have a single taproot, rodents such as pocket gophers can reduce stands; kangaroo rats and mice also cause damage (340). Alfalfa is more subject to overgrazing than grasses, and is thus rendered more susceptible to drought and winter injury. Crown-spreading or creeping alfalfas (eg. "Nomad", "Rhizoma", "Sevelra") are more persistent and, once established, are not injured as readily by rodents (340).

Susceptibility to Disease and Insect Damage

Intensive breeding work has increased its resistance to plant diseases and insects (179). Selected varieties are resistant to bacterial wilt ("Range") (191). So-called Flemish types, originating in Europe, are less resistant to diseases than Standard types, developed in North America (191). Susceptible to bacterial wilt, winter crown rot or snow mold, crown bud rot, leaf spot, and yellow leaf blotch. These problems can be avoided or overcome with prescribed management practices or selection for resistant varieties. Insects causing damage include lygus bug, Plagiognathus sp., and the pea aphid, Acyrthosiphon pisum. These are controlled with chemicals (191).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

M. sativa included as a plant suitable for soil stabilization on disturbed lands in northwestern Colorado (446). Contributes nitrogen.

Adaptation to Disturbance

Rated as relatively good (338).

Competitive Ability

In grass-legume mixtures applied to coal mine wastes (Hat Creek, British Columbia), fall rye probably inhibited development of alfalfa and other species by better taking available moisture and nutrients (187). Similar observations are indicated at Grande Cache where application of nitrogen, in particular, results in vigourous growth of grass, supplanting alfalfa if the latter does not comprise at least 20% of the seed mixture (269). Seeding of tailings sand slopes resulted in good growth of alfalfa and other legumes at low rates of fertilization; as application rates increased, grasses became dominant (359).

Commercial Value

Feed for livestock and wildlife pasture, hay, and erosion control (175). Also used for production of processed alfalfa livestock feed (391).

Palatability and Nutritive Value

Wildlife forage for pronghorn antelope and mule deer (Wyoming) (381). Alfalfa forage is noted for its high protein content (191). Palatable, but causes bloat if the stand is not mature, or if grasses do not comprise at least 50% (175). When mixed with native hays, it increases their digestibility and apparent palatability; high protein and mineral contents make it an excellent supplementary feed (405). M. sativa, in particular, is noted for moderate use by mule deer in spring, and heavy use in summer and fall, where available (245). Potential problems for livestock include photosensitization, toxic concentrations of nitrate, and bloat (226).

Seed or Planting Stock Availability

Seed for many varieties has been selected for specific performance or disease resistance. Selected varieties suitable for Alberta include "Ladak", "Beaver", "Drylander", "Kane", "Rambler", and "Roamer" (391). Many licensed varieties are available. Alfalfa (M. sativa) seeds retain viability for at least 14 years storage. "Peace" is a new winter hardy forage variety and "Anik" is a new reclamation variety. Approximately 210 000 seeds/lb for M. sativa (639).

Methods and Ease of Establishment

Can be drill or broadcast seeded (427). In northwestern Colorado, at elevations above 2 400 m, no more than one-fourth of the mix should be alfalfa, with three-fourths grass (427). Experimentation near Grande Cache, Alberta has determined that alfalfa should comprise at least 20% of a grass-legume mixture in order for the alfalfa to respond to competition from the grasses (269). Liming and other management practices enable alfalfa to persist on acid soils (191). Seed should be no deeper than 2.5 cm. Seeding is not recommended in dry areas where surface soil seldom remains moist enough for germination. The best time to seed is in early spring (338). Fall/spring seeding at a rate of 8 to 15 lbs PLS/ac has been recommended (639); 15 to 20 lbs PLS/ac for the Eastern US (712). Establishment potential by transplanting rated as relatively good (338).

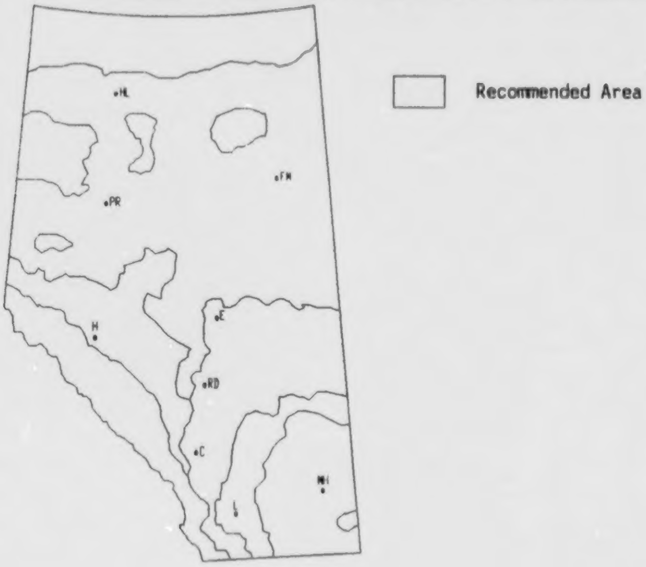
Current Status for Reclamation

In Alberta, revegetation trials have demonstrated successful alfalfa growth on coal mine overburden waste in mountain and foothill settings (371, 364), prairie strip mine spoil materials (279), coal bottom ash and fly ash materials (271), and ash lagoon material at a coal power generation site (305, 696). Growth success is generally expressed in terms of establishment and cover development relative to other legumes tested (45, 143, 86, 187), and referenced to site-specific surface treatments. Review indicates mixed success on high-elevation sites in Alberta, probably due to varieties selected, growth media, and local conditions for plant growth (723). The new variety "Anik" is noted for its extreme winter hardiness and low biomass, and may be useful at high-elevation sites. "Rambler" and "Drylander" performed adequately on a variety of overburden and waste rock materials at 1 675 m ASL near Cadomin (380) but were ultimately considered a failure (723). In Colorado, however, successful seedings and growth of alfalfa were noted on strip mine spoils at 1 980 m to 2 280 m ASL (43). "Rangelander" and "Anik" showed excellent survival and vigour after three years, in tests in the Upper Mackenzie region of the boreal forest (latitude 63° N). While seed production was good, viability was likely poor due to the short growing season (644). "Rambler" alfalfa has persisted well in mixes on overburden and amended tailings sand for 10 to 14 years without maintenance fertilization (644). "Rambler" dominated a grass - legume mixture after two seasons on coarse-textured soil in an arid climate (717). In British Columbia, alfalfa grew favorably on disturbed sites in subalpine areas from 1 150 to 2 100 m (494, 498), but did not set seed. Other cases of successful alfalfa growth for reclamation include volcanic waste rock in the southern interior of British Columbia (143), gypsum waste with extremely acid reaction (163), pipeline berm materials (436, 195), coal mine wastes in British Columbia (187), coal spoil in Kentucky (423), and rehabilitation of wildlife habitat on disturbed lands in northwestern Colorado (446, 447).

Key features of alfalfa advantageous for reclamation use include adaptability to a wide range of ecological settings, with many commercially licensed varieties available for local conditions and land uses throughout Alberta. Variety in rooting types, combining other favored characteristics (superior forage yield and quality, nitrogen fixing capability), aids species selection planning. Limitations include sensitivity to acid soils and high elevations. Alfalfa generally complements grass species selection and satisfies criteria for a number of reclamation objectives and land uses (eg., agricultural production, wildlife habitat, etc.).

Melilotus alba

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance			X	X		
Salt Tolerance				X		
pH Tolerance	Acid				X	
	Base		9.2		8.0	
Winter Hardiness				X		
Erosion Control			X	X		
Persistence					X	
Palatability				X	X	
Browse Tolerance				X		
Moisture Preference		Dry to moist.				
Soil Preference		Wide range, clay to sandy.				

Melilotus alba Desr., **M. officinales** (L.) Lam.

SPECIES BIOLOGY

Taxonomy

Sweet Clover (Melilotus spp.) (138); White Sweet Clover (M. alba); Yellow Sweet Clover (M. officinales)

Origin and Range

Introduced from Europe and Asia (78). Circompolar. Throughout North America and also introduced into South America, South Africa, New Zealand and Australia (214).

Growth Habit

An erect plant; M. officinales 0.2 to 2 m high and M. alba 0.6 to 2.5 m high (78). Flowers of M. alba are white, those of M. officinales are yellow; also M. officinales has shorter and finer stems, more spreading growth, and finer leaves than M. alba (138). Taprooted. Sweet clover has a fast rate of growth (190). A dwarf form of sweet clover is apparently found on high peaks in British Columbia (185). White flowers (690).

Nitrogen Fixing

Sweet clover fixes atmospheric nitrogen (331).

Longevity

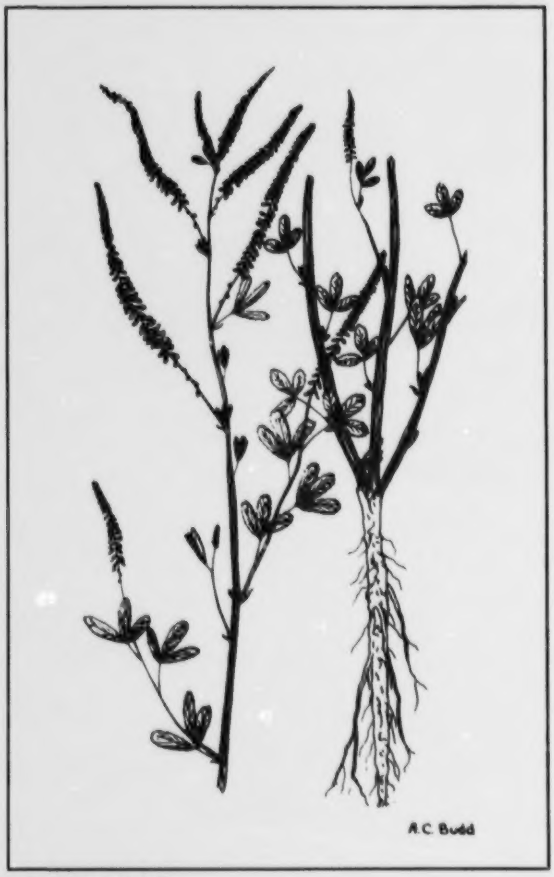
White sweet clover and yellow sweet clover are cool season (713) biennials (269).

Self Propagation

Seed; reseeds on some sites (500).

Ecological Setting

Introduced as a forage plant but common along roadsides and in waste areas throughout the prairies (78). The effective environmental zone for sweet clover (moisture equivalent) has been variously reported to be approximately 38 to 85 cm/year (500); 35 to 101 cm (713); 25 to 30 cm minimum (639). In southeastern B.C., sweet clover grew well at 1 800 m to 2 230 m ASL but growth above 2 430 m was poor (162). Sweet clover has proved to be a winter hardy species in Alaska (5).



TOLERANCES

Soil Preferences

Melilotus spp. are adapted to a wide range of soil textures. Sweet clover is suited to moist (180), or dry to moist soil conditions (190). Optimum soil depth for sweet clover is more than 62 cm and optimum slope is 0 to 8% (447). They have a poor tolerance of wetness and flooding (5). Growth is reported to be good on soils that have textures ranging from sandy to clayey (447). Sweet clover has been recommended for revegetation use in Kentucky on steep (>70% slope) and stony mine spoils (423).

Nutrient Requirements

Sweet clover has very low to medium nutrient requirements (190, 446, 500). Since legumes fix atmospheric nitrogen, they need less fertilizer than grasses (278). In growth chamber studies on alkaline, sodic spoil material, yield of yellow sweet clover increased with the addition of NPK fertilizer. This was essentially due to P and inclusion of N with P usually depressed the yield. A sulphuric acid amendment increased the P concentration of the plants (368).

Soil Reaction

Melilotus spp. have poor acid tolerances (5). The pH tolerance range of sweet clover is 6.0 to 8.0; 5.5 minimum (713). It has been recommended for revegetation of alkaline and calcareous (pH >7.3) mine spoils in Kentucky (423). White sweet clover was used successfully to revegetate alkaline (pH 9.2) asbestos mine tailings in Quebec (309).

Soil Salinity

Sweet clovers (Melilotus spp.) are salt tolerant species (163). Tolerates moderate salinity (3 to 5 mS/cm) (500). Yellow sweet clover has been successfully established on sodic mine spoils near Estevan, Saskatchewan (447).

Drought

Melilotus spp. have good drought resistance (5).

Heavy Metals and Hydrocarbons

Sweetclovers (M. officinales and M. alba) accumulate molybdenum. This uptake is favored by alkaline soil conditions. Copper to molybdenum ratios of less than 5 to 1 have been reported for sweet clover growing on mine spoils in the northern great plains. These ratios could cause molybdenosis in cattle and sheep (142). White sweet clover was one of the best legumes on an ash lagoon near Lake Wabamum after three years (696).

Shade

Does not tolerate shading.

Grazing or Mowing

The minimum stubble height required by Melilotus spp. has been reported as 10 cm (5). Presumed to tolerate grazing satisfactorily.

Susceptibility to Disease and Insect Damage

No specific susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Sweet clover has an erect habit and a tap-root (423). The root system is deep and abundant. Sweetclover has the ability to convert insoluble phosphorus into forms more readily available to other plants (500). Can be used to build up organic matter content of soils (138). Yellow sweet clover has been found useful for stabilizing roadcuts, and other disturbed areas in Utah (336).

Adaptation to Disturbance

Sweet clover is a pioneer on Alberta (331, 358) and British Columbia mine spoils (384). When planted, the sweet clover generally does well for 3 to 4 years and then is replaced by foxtail barley and weedy species. Site productivity declined to very level on Alberta mine spoils with the decline in sweet clover (85). White sweet clover has been reported as a pioneer on serpentine asbestos mine wastes (pH 9.2) in Quebec (310). It is often found as a roadside weed (34, 78).

Competitive Ability

Sweet clover has been rated as moderately aggressive in the first year of planting, and can be very competitive in the second year of growth (500). Sweet clover seeded on mine spoils at Aleece Lake, B.C. had the poorest germination of legumes seeded and appeared to suffer from competition with seeded grasses. It performed best on the edge of plots where competition was less (187). However, sweet clover seeded with rye and spring vetch had strong growth (166). Yellow sweet clover established on sodic mine spoils in Saskatchewan spread to other plots seeded with grasses, and after four years became a dominant species in those plots (180).

Commercial Value

Hay, pasture (423). Some varieties outyield alfalfa (138). Bee pasture (138). Nitrogen fixation (331).

Palatability and Nutritive Value

Sweet clover has a well-balanced nutrient content during its early growth, but loses much of its protein as plants mature. In its early growth stage it provides palatable pasture for all classes of livestock, and when cut early and cured it makes a desirable hay (138). However, spoiled or improperly cured hay or silage may be poisonous to cattle; sheep and rabbits have proved susceptible in experiments (226). There is some controversy regarding dicoumarin problems from sweet clover. This substance may cause internal and external bleeding in cattle. Some workers claim that dicoumarin may arise only when cattle are fed wetbale or silage sweet clover, while others maintain that it can cause problems in cattle feeding on range sweet clover (72). "Cumino" and "Polara" are low coumarin varieties licensed in Canada, with little danger of causing hemorrhage or sweet clover disease in Canada (138). Forage of "Norgold", a recently developed variety, contains only traces of coumarin with no risk of this disease. Tough fibres also develop in over-mature hay. These may cause "hair balls" or obstruction of intestines (226). It provides good forage for mule deer, game birds and small mammals. It provides good cover for game birds and small mammals and fair cover for mule deer (296). Light to moderate use by mule deer has been reported (245). Yellow sweet clover and alfalfa were reported to compose 40% of the July diet of pronghorn antelope in Wyoming (381).

Seed or Planting Stock Availability

Seed available from most seed dealers. Approximately 260 000 seeds/lb (639).

Methods and Ease of Establishment

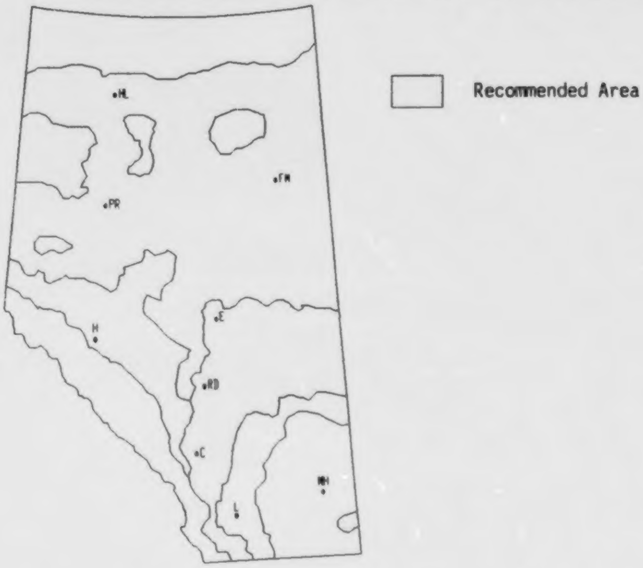
Spring hydroseeding was found to be more successful than fall hydroseeding in trials at Luscar, Alberta (1 800 m ASL) (144). Yellow sweet clover has low establishment requirements (446). Typical purity/germination is 99/85% (268). Sweet clover has also been successfully hydroseeded on road embankments in B.C. (162). Spring/fall seeding at a rate of 10 to 15 lbs PLS/ac has been recommended (639, 713).

Current Status for Reclamation

Sweet clover has been used in hydroseeding trials on mined land in the subalpine near Luscar, Alberta (144). Germination of sweet clover was low when hydroseeded on sand dunes near Lesser Slave Lake, northern Alberta. Growth of surviving plants was poor on the dune crest but satisfactory in all other topographic positions. White sweet clover has been suggested as a species with potential use for revegetation in the Rocky Mountains (426). Regarded by some as a green manure crop only in revegetation (500). Mixed sweet clover (M. alba and M. officinales) has been eliminated from seed mixes used for revegetation of oil sands tailings in northern Alberta because of poor performance (152), although yellow sweet clover has been suggested as a suitable legume for revegetation of oil sands tailings on moist to dry sites (12). Sweet clover provided the initial cover on unseeded overburden and amended tailings sand persisting strongly for 4 to 5 years before grasses become dominant. Sweet clover has persisted as a minor component in mixed seedings for 15 years on amended tailings sand with low-maintenance fertilization (641). White sweet clover has been used successfully for revegetation of land disturbed during mining operations in the interior dry belt of B.C. (332). Sweet clover has also been successfully hydroseeded on road embankments in B.C. (162). It is often planted in association with trees and shrubs (466). White sweet clover is used for reclamation in both Europe and the USA. (316, 2, 331). Yellow sweet clover is widely used for rehabilitation of dry, sodic or alkaline sites in Alberta, Saskatchewan and B.C. It is particularly important for mine reclamation near Estevan, Saskatchewan. It has been found suitable for reclamation use in the mid-grass prairie of central and eastern North and South Dakota. Annual precipitation in this area is about 40 to 50 cm and mainly cool season native grasses are used (327). It tends to out-compete seeded grasses and other legumes because of its shrub-like growth formation. Significant growth only every second year (biennial) is a disadvantage for reclamation (P. King, pers.comm.).

Onobrychis viciaefolia

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base				X	
Winter Hardiness			X		
Erosion Control			X		
Persistence				X	
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Moist.				
Soil Preference	Loamy to sandy, well drained.				

Onobrychis viciaefolia Scop.

SPECIES BIOLOGY

Taxonomy - Sainfoin

Origin and Range

Introduced to North America. Originated in Europe. It has established in British Columbia, western Washington, Montana, and probably elsewhere (199).

Growth Habit

Tall leafy legume (199), with erect stems to 60 cm or less, and deep roots (426). Height of various cultivars ranges from 48 to 85 cm (139). Flowers pink to purplish (690).

Nitrogen Fixing - Fixes atmospheric nitrogen.

Longevity

Short-lived (175) perennial herb (405). Relatively tolerant of frost (179).

Self Propagation - Seed.

Ecological Setting

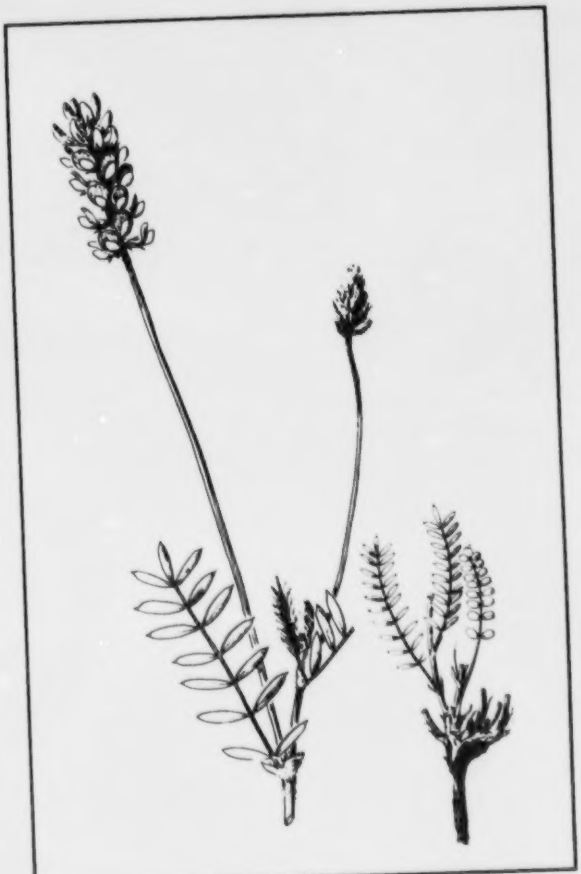
Common sainfoin is a forage plant introduced to agricultural areas, but has spread to roadsides and waste places (426). Common sainfoin grew "satisfactorily" on high-altitude sites (1 650 m to 2 010 m ASL) in the Fording River valley of British Columbia (162). Requires a minimum of 38 to 46 cm of precipitation (639); performs best in areas with 40 cm or more mean annual precipitation (426).

TOLERANCES

Soil Preferences

Common sainfoin is adapted to well drained soils of sandy to loamy texture (456). Good growth has been recorded on coarse textured materials (gritstone, colluvium and glacial gravels) as well as on difficult finer textured surfaces (bentonitic clay and baked clay) in a hot, arid B.C. setting (439).

Nutrient Requirements



Revegetation trials in the northeast coal block of British Columbia determined that little difference in growth could be seen between two levels of fertilization, although comparisons may be meaningless since growth was poor in both cases (70). As with most legumes, it can be inferred that nutrient requirements are fairly low, and competition with grasses would be most successful at low fertilization rate.

Soil Reaction

Growth chamber studies, testing plant growth on tailings sand and overburden materials, indicate that common sainfoin could be grown successfully in the pH range normally encountered at oil sands sites (slightly acid to slightly alkaline); under some conditions (low pH) it outperformed alfalfa in development of root nodules (404).

Soil Salinity

Growth chamber experiments in the Alberta oil sands tested the growth of various plant species on a tailings sand mix artificially salinized. Common sainfoin had the highest salinity tolerance of the legumes tested (cicer milk vetch and alfalfa) (404).

Drought

Generally considered to be drought resistant (179).

Heavy Metals and Hydrocarbons

Common sainfoin was tentatively judged to warrant further study in field trials on lean oil sands (7.8% oil content) in the Alberta oil sands, although alfalfa had a substantially better root yield. None of the legumes tested provided adequate growth on a heavy oil sand mix (oil content of 14.4%) (404). Appears not to do well on coaly waste materials and fly ash (439). No other tolerances were noted from the literature reviewed.

Shade

Presumed to be relatively shade intolerant because of its use of agricultural settings.

Grazing or Mowing

Status as a forage plant indicates at least moderate grazing tolerance.

Susceptibility to Disease and Insect Damage

Considered to be "remarkably free" from insect pests and most plant diseases, although crown rot may occur (179).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Sainfoin is characterized as a deep-rooted legume (426) which may be useful for erosion control; however, its short life is not conducive to long-term erosion control (175).

Adaptation to Disturbance

Selected to grow in agricultural settings so presumably adapted to disturbance. Often considered a weed (405).

Competitive Ability

Grows well as a companion crop with grasses.

Commercial Value

Used for hay and pasture (426). Flowers are attractive to bees (179). The species may therefore be important for honey making. May also have erosion control value. A nitrogen fixer with soil nitrogen improvement ability.

Palatability and Nutritive Value

Widely used in Europe for hay and pasture, and locally important in portions of the western great plains and northern intermountain region in the United States (426). Considered equal to alfalfa in feed quality (179). It does not cause bloat (426). Observations of legume growth on revegetated mine spoil in Colorado indicate intensive grazing of common sainfoin by wildlife (449).

Seed or Planting Stock Availability

Seed is commercially available. "Eski" and "Remont" are two cultivars available in quantity; "Remont" was selected for its superior regrowth characteristics (426). Thirteen other cultivars have been tested for yield in Canada (139). Seed supply is apparently limited (175). "Melrose" and "Nova" are licensed in Canada. "Nova" is noted for winter hardiness. Approximately 30 000 seeds/lb (639).

Methods and Ease of Establishment

Establishment is usually by seed. Typical purity/germination is 97/80% (417). Successfully seeded on coal surface-mined lands in Montana by a rangeland drill seeding a grass-legume mixture. Good establishment during second growing season following an apparent slow start during initial season (117). Spring seeding at a rate of 35 to 45 lbs PLS/ac has been recommended (639).

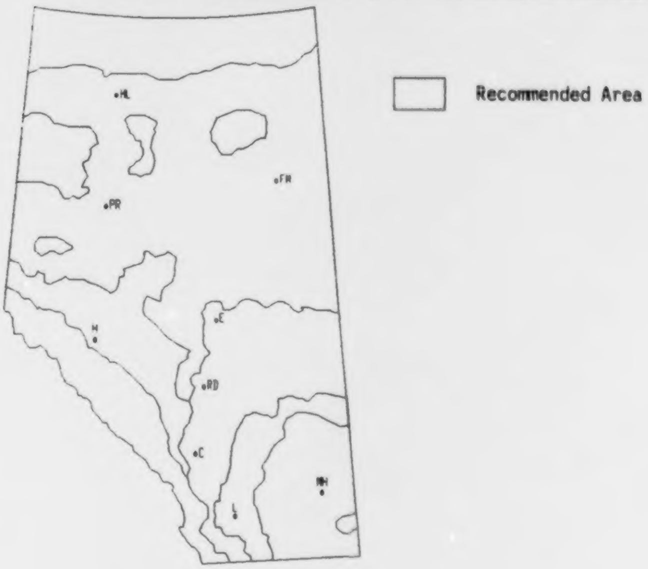
Current Status for Reclamation

Common sainfoin is a fairly widely used hay and pasture species, both in Canada and the northern US. Its moisture requirements are moderate, and therefore it is less successful in dry prairie situations than in the mountains or moist parkland. Performance is generally acceptable on waste overburden in the forested regions, however persistence is poor.

Although the species is not regarded as particularly successful at high elevations, common sainfoin showed satisfactory growth on high elevations in southeastern B.C. (2 010 m ASL) (162). Common sainfoin is currently used in grass-legume mixtures at oil sands sites (152) and has been tested in growth studies (404). In the Smoky River area, first year evaluations of growth ranged from "poor" to "good"; no plants survived the following winter, presumably due to the harsh overwintering conditions of the alpine (1 950 m ASL) tundra. Sainfoin performed well in mixed seeding and in pure stands on overburden waste in the lower subalpine region near Hinton (647) and Canmore, respectively. The cultivar "Krasnodar" was used (377). First-year results on coal mine wastes in the Hat Creek Valley of British Columbia indicate that common sainfoin ("Melrose") showed good emergence on all materials except carbonaceous soils (shale and coal waste) and fly ash. It clearly outperformed all other legume species tested (Drylander alfalfa, sweet clover, red clover). Additions of topsoil seemed beneficial (439). Revegetation trials in the northeast coal block of B.C. (elevations 1 065 to 1 720 m) indicated poor growth of sainfoin below treeline; however all species grew poorly above treeline (70). Comparative evaluation of several legumes for persistence and forage production on mountain meadows in Colorado indicated poor performance of sainfoin relative to other legumes (417).

Oxytropis spp.

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance			X		
pH Tolerance Acid					
pH Tolerance Base			8.4		
Winter Hardiness		X			
Erosion Control		X			
Persistence			X		
Palatability				X	
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Clay loam to sandy loam.				

Oxytropis spp.

SPECIES BIOLOGY

Taxonomy

Loco-weed (O. monticola); Alpine Loco-weed (O. cusickii).

O. monticola A. Gray ssp. monticola, also O. campestris (L.) DC. var. gracilis (A.Nels.) Barneby; and O. cusickii Greenm., also O. campestris (L.) DC. var. cusickii (Greenm.) Barneby.

Origin and Range

Native. Alaska, south in the mountains to Colorado, and Wyoming. Scattered representation around Hudson Bay, Labrador and Nova Scotia. Also northwestern Europe (214).

Growth Habit

Plants of this genus are usually without stems (78). Erect leaves 110 to 310 cm tall (690). Oxytropis spp. generally have a bunch growth habit (436). Root:shoot ratio is high (436). Flowers blue, purple, whitish or yellowish (690).

Nitrogen Fixing - Fixes atmospheric nitrogen.

Longevity

Perennial herb (788). The species is regarded as being winter hardy (240).

Self Propagation - By seed.

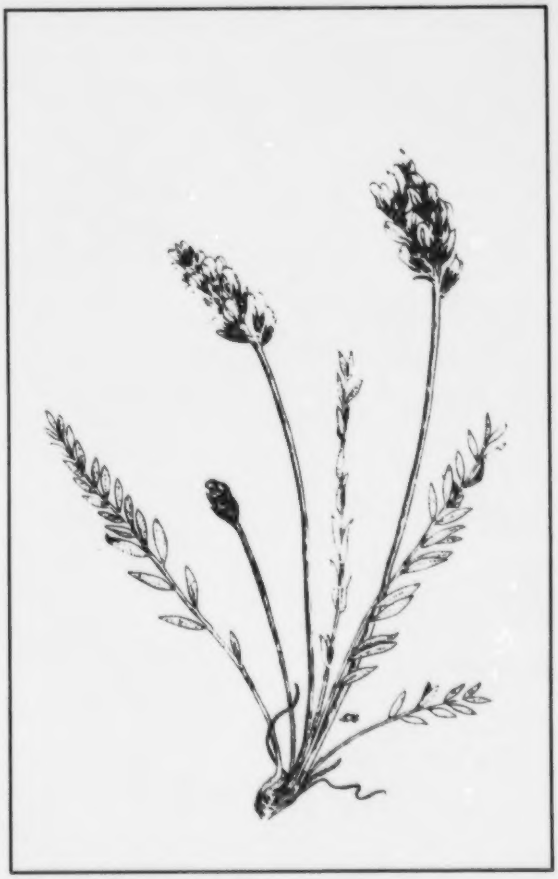
Ecological Setting

Oxytropis monticola is common in open woodlands and throughout the prairies where it is not excessively dry. O. cusickii occurs at high altitudes in the Rocky Mountains (78, 690).

TOLERANCES

Soil Preferences

Oxytropis campestris prefers sandy loam to loam clay soils. It will not tolerate water saturated soils such as heavy clays.



Nutrient Requirements

Loco weeds in general are tolerant of low nutrient conditions (436).

Soil Reaction

Oxytropis cusickii has been reported as a pioneer on alkaline (pH 8.0 to 8.4) glacial outwash in Alaska (332).

Soil Salinity

Tolerant of moderately saline soils.

Drought

Loco weeds in general are drought tolerant (436).

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Will not tolerate excessive shade.

Grazing or Mowing

Moderately tolerant of grazing since it is generally avoided by livestock and wildlife.

Susceptibility to Disease and Insect Damage

Locoweed species found naturally in northern areas are resistant to northern diseases (436).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The nitrogen fixing ability and high root:shoot ratio make this species an excellent soil builder with a high erosion control capability.

Adaptation to Disturbance

Oxytropis cusickii has been reported as a pioneer on gravel outwash on the Muldrow Glacier, Alaska (332). *Oxytropis monticola* has been reported as a pioneer on coal mine spoil near Cadomin, Alberta. This site is located at 1 675 m ASL and has severe climatic limitations (wind and drought) (357).

Competitive Ability

Good competitive ability on preferred sites.

Commercial Value

No commercial value, except soil building and nitrogen fixation.

Palatability and Nutritive Value

Some *Oxytropis* spp. are poisonous to livestock as they contain alkaloids which cause "loco" disease (312).

Seed or Planting Stock Availability

Seed is easily collected from native stands, although germination rate is low (268).

Methods and Ease of Establishment

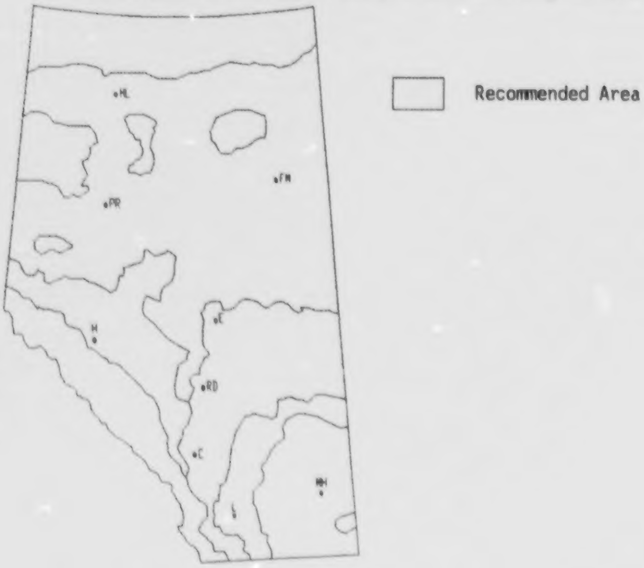
Late yellow loco-weed often has a lengthy dormancy period before germination (431). Germination of *Oxytropis* spp. has been reported as about 10% (268).

Current Status for Reclamation

Late yellow loco-weed is currently being evaluated for growth on tailings sand from Yellowknife (332). Very little use is otherwise apparently made of it. Late yellow loco-weed is a drought tolerant species and tolerant of saline soils. Its ability to fix atmospheric nitrogen and its high root to shoot ratio are attributes which suggest this species has potential for reclamation purposes in Alberta.

__Trifolium__ __hybridum__

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid			X		
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence				X	
Palatability		X			
Browse Tolerance		X	X		
Moisture Preference	Moist, tolerates seasonal flooding.				
Soil Preference	Clay to sandy loam.				

Trifolium hybridum L.

SPECIES BIOLOGY

Taxonomy - Alsike Clover

Origin and Range

Origin is obscure (138). Introduced from Europe (331). Cultivated in Alaska, throughout Canada and the United States. Scattered circumboreal distribution (214).

Growth Habit

Alsike clover is an erect to decumbent plant, 20 to 80 cm high (312, 78). Stems are usually much branched (690). Flowers commonly pinkish (690).

Nitrogen Fixing - Fixes atmospheric nitrogen

Longevity

Alsike clover is a short-lived perennial species (690). "Aurora" and "Dawn" varieties are noted for winter hardiness (138). Generally dies in two years (713)

Self Propagation - Primarily by seed.

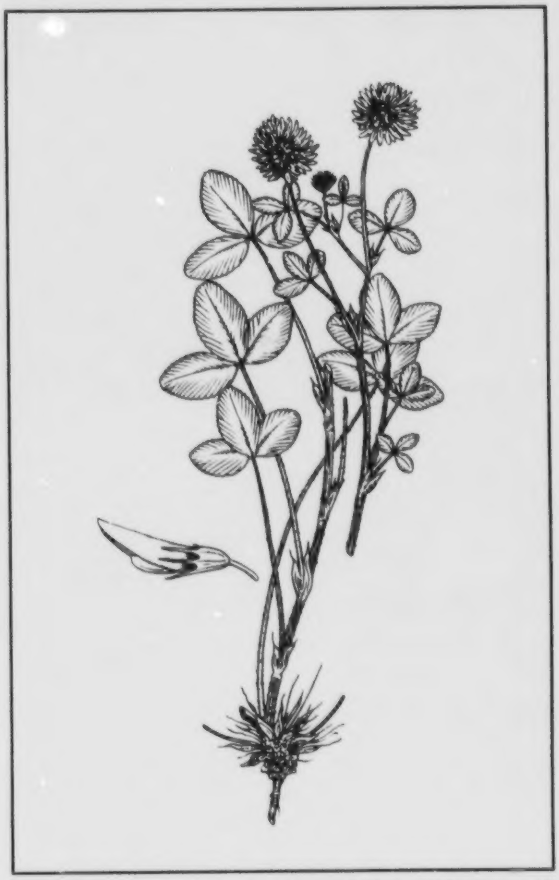
Ecological Setting

Escaped from cultivation. Alsike clover is common in waste places, along roads, and in wooded areas of the prairies (78). It is well adapted to cool climates (256). Alsike clover did not persist more than two years at several high altitudes (>2 100 m) sites in Colorado (417). Alsike Clover has been recommended for use in the aspen and subalpine zones of the intermountain region of Utah and Nevada. In areas with annual precipitation less than 34 cm, planting should be restricted to moist lowlands (424). The effective environmental zone (moisture equivalent) has been variously reported to be 45 to 135 cm/year (500) and 38 to 101 cm (713); minimum of 89 cm (639).

TOLERANCES

Soil Preferences

Alsike clover is adapted to soils with moisture regimes ranging from well and moderately well drained to poorly drained soils that are usually waterlogged (5) and seasonally flooded (12, 256). Best growth can be expected on moist soils. The optimum slope is 0 to 8% and the optimum soil depth is more than 62 cm. Growth on sandy soil is fair, and on loam soil and clayey soil growth is good (447).



Nutrient Requirements

Alsike clover requires moderate amounts of phosphate and potassium for satisfactory growth (500).

Soil Reaction

Alsike clover can tolerate acid and alkaline conditions (256). It is not as sensitive to low soil pH as alfalfa (Medicago spp.) and sweetclover (Melilotus spp.), or as tolerant of low pH as sericea lespedeza (Lespedeza cuneata) and birdsfoot trefoil (Lotus corniculatus) (27). Alsike clover has good acid tolerance (5). It does well on soils that are too acid for red clover (Trifolium pratense) and it can tolerate more alkalinity than most other clovers (138). Lower limit is 5.0 (713).

Soil Salinity

Alsike clover is not generally tolerant of salinity (500). Salt tolerance has been rated as moderate (424). The limit of soil salinity tolerance has been reported to be 2 to 4 mS/cm (468).

Drought

"Aurora" alsike clover is drought tolerant (12). Overall, alsike clover has fair drought tolerance (5).

Heavy Metals and Hydrocarbons

Alsike clover has a high tolerance of oil (282). No other tolerances were noted.

Shade - Prefers bright, open locations.

Grazing or Mowing

It is presumed that the species has moderate to good tolerance to grazing and mowing.

Susceptibility to Disease and Insect Damage

No specific disease or insect pest information was located.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

This species is not rhizomatous (41). The tap root may be up to 1 m deep (500). Its value for soil building lies in its contribution of fixed nitrogen and in its fibrous lateral roots.

Adaptation to Disturbance

Alsike clover is planted, and has satisfactory survival and growth, under a wide variety of disturbed soil situations including roadsides, cultivated fields, and on denuded industrial sites. It has a good rate of spread (424).

Competitive Ability

Alsike clover is only weakly aggressive (500).

Commercial Value

Alsike clover is grown on wet soils, mixed with grasses, for hay (138). Primary use is as a nitrogen supplier, for hay and pasture, and for site rehabilitation.

Palatability and Nutritive Value

Yield potential for alsike clover has been rated as moderate (5). It is considered a palatable species (41). Alsike clover may cause photosensitive irritation in livestock (226), and bloat (639). Forage value has been rated as good for mule deer, game birds, and small mammals. The cover value is poor for mule deer and game birds, and good for small mammals (447).

Seed or Planting Stock Availability

Licensed varieties for use in Canada include "Aurora", "Dawn" and "Tetra" (138). Approximately 680 000 seeds/lb (639).

Methods and Ease of Establishment

Purity/germination is typically 99/85% (132). Alsike clover has good seedling vigour (41). Ease of establishment has been rated as good (424). The species is usually seeded in combination with grasses to provide a source of fixed soil nitrogen. A seeding rate of 5 to 10 lbs PLS/ac has been recommended for the Eastern US (713); 6 to 8 lbs PLS/ac in the spring for the west (639).

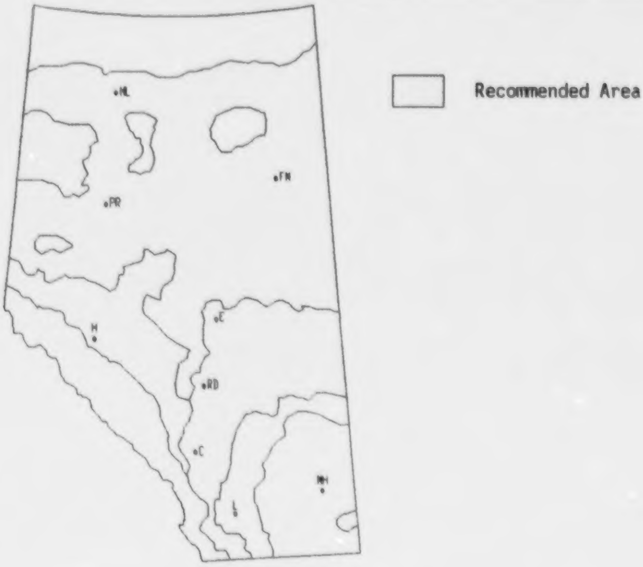
Current Status for Reclamation

"Aurora" alsike clover gave satisfactory first year results when seeded on raw overburden at Cadomin (subalpine), Alberta (364) but failed to persist (705). Alsike clover was reported to grow above treeline in northeastern B.C., but only in sheltered moist pockets (70). "Aurora" performed well in mixtures on disturbed soils near Cold Lake and in the oil sands on amended tailings sand and on overburden, generally peaking after three or four seasons and then declining rapidly (641, 685, 704). Alsike clover is one of several grasses and legumes which were successfully established on organic and nutrient enriched coarse asbestos tailings (pH 9.2) in Quebec (309). Alsike clover has been recommended for revegetation of disturbed sites below 3 330 m ASL in Colorado (462). "Dawn" alsike clover is recommended for areas with excessive acidity, alkalinity, spring flooding or a high water table (209). "Aurora" alsike clover has been used for revegetation in Alaska (298).

Alsike clover is a short lived, non-spreading legume. It can tolerate both moderately acid and alkaline soils. It is well adapted to cool climates and wet soils and will withstand flooding for long periods. It has potential use as a companion crop for revegetation of disturbed areas where its nitrogen fixing ability is an asset.

Trifolium pratense

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance					X	
Salt Tolerance					X	
pH Tolerance	Acid				X	
	Base			X		
Winter Hardiness			X			
Erosion Control				X	X	
Persistence					X	
Palatability			X			
Browse Tolerance			X			
Moisture Preference		Moist, tolerates flooding.				
Soil Preference		Silty clay to sandy loam, well to moderately well drained.				

Trifolium pratense L.

SPECIES BIOLOGY

Taxonomy - Red Clover

Origin and Range

Introduced from Europe (78). It is a native over most of Europe and parts of Asia (138). Cultivated in Alaska, British Columbia east to Newfoundland, south to California in the west and Florida in the east (214). Circumboreal distribution (214).

Growth Habit

An erect or spreading, widely branched herb. Red clover is usually 40 to 80 cm tall (312). There are two types in Canada: early flowering or double-cut and late flowering or single-cut. The early flowering type produces two hay crops per year (138). Not rhizomatous (41). Flowers red, pink or nearly white (690).

Nitrogen Fixing

Red clover fixes atmospheric nitrogen. Good nodulation and nitrogen fixation have been obtained on acid soils (down to pH 3.5) by applying the appropriate Rhizobia and a small amount of molybdenum with the seed at the time of planting (38).

Longevity

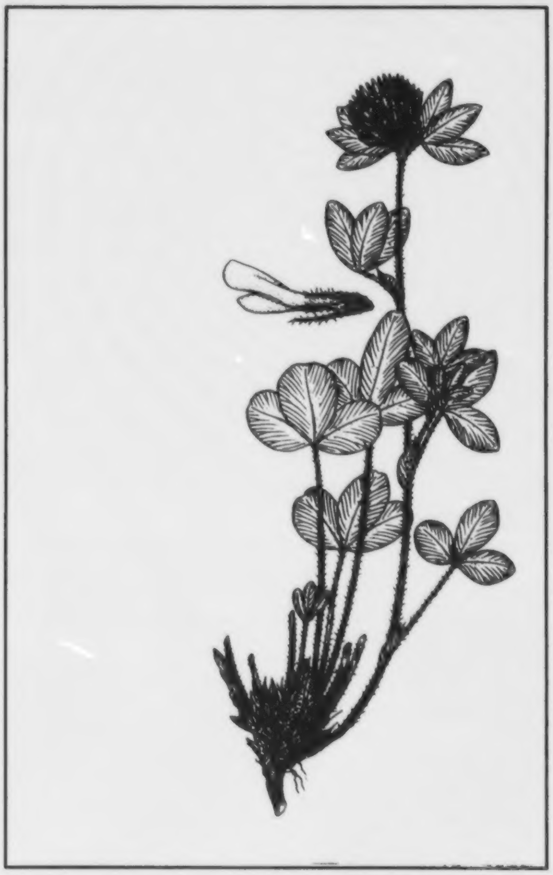
Biennial or short-lived, cool season (713) perennial species (78). Under favourable conditions it may survive for three growing seasons (426). The early flowering type is a biennial or short-lived perennial whereas the late flowering type is usually always perennial (138). "Alaskaland' red clover has excellent winter hardiness (240). "Altaswede" red clover is winter hardy (12). Red clover persisted from 2 to 5 years at several high altitude (over 2 100 m ASL) sites in Colorado (417).

Self Propagation

Propagation is primarily by seed.

Ecological Setting

Red clover is the most widely grown of all true clovers. It is best adapted to cool or warm summer temperatures where there is adequate moisture throughout the growing season (138). This species has escaped from cultivation (312). It is rarely found in the western part of the Canadian prairies but is fairly common in waste areas in the east and north (78). It is mainly used in the eastern United States but can be used on irrigated areas in the western United States except the arid southwest (426). In areas with less than 30 cm precipitation planting should be restricted to moist lowlands (424). Precipitation range is 50 to 127 cm (713); 89 cm minimum (639).



TOLERANCES

Soil Preferences

Red clover is adapted to soils with medium textures from sandy loam to silty clay loam (5). It has fair tolerance to wetness and flooding (5). For good growth, red clover requires ample moisture and good drainage. It grows well on Luvisolic and Chernozemic soils (391). The optimum slope is 0 to 8% and the optimum soil depth is more than 62 cm. Growth is also good on sandy soil, loamy soil and clayey soil (447).

Nutrient Requirements

Presumed to have no more than modest nutrient requirements.

Soil Reaction

Red clover is not as sensitive to low soil pH as alfalfa (Medicago spp.) and sweet clover (Melilotus spp.), or as tolerant of low pH as birdsfoot trefoil (Lotus corniculatus) (27). It has poor to fair acid tolerance (5). Lower limit is 5.0 (713).

Soil Salinity

Red clover has low tolerance to soil salinity (0 to 4 mS/cm) (163).

Drought

Red clover has fair drought tolerance (5).

Heavy Metals and Hydrocarbons

No tolerances noted from the literature.

Shade

Prefers open situations and good light.

Grazing or Mowing

Presumably relatively tolerant to mowing and grazing.

Susceptibility to Disease and Insect Damage

"Altaswede" is susceptible to powdery mildew and northern anthracnose. "Dolland" is moderately resistant to northern anthracnose, leafhoppers and wilt. "Norlac" is resistant to northern anthracnose (138).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

This species is not rhizomatous (41). Red clover has a tap root system with many side branches. It is not as deep rooted as alfalfa (138). Erosion control ability is presumed to be slight; however, the species is valuable for its nitrogen fixing abilities.

Adaptation to Disturbance

Red clover has a good rate of spread (424). It has been reported as a volunteer on reclamation test plots near Wabamun, Alberta (305). Red clover had good performance on sites disturbed by mining above 1 650 m ASL in southeastern B.C. (494). It commonly occurs on disturbed roadsides, and is adapted to planting under cultivation.

Competitive Ability

Double cut red clover seeded in a mixture on reclamation test plots at Aleece Lake, B.C. showed growth on plot edges where competition was presumably less (187).

Commercial Value

Red clover is an important forage crop (426). Because of its rapid growth in the first year it should be seeded with grasses to reduce the hazard of bloat (391). It has been recommended for revegetation of critical sites in Canada. It is commonly used on roadsides for forage and hay, and to provide ground cover.

Palatability and Nutritive Value

Red clover has high protein content and is an excellent forage species (256). Forage yield for livestock has been rated as moderate (5). It is highly palatable (427). It may cause photosensitization in livestock. The grazing of a second cut has occasionally caused slobbering and loss of appetite in cattle and sheep (226). Forage value has been rated as good for mule deer, game birds and small mammals. Cover value is poor for mule deer, fair for game birds and good for small mammals (447).

Seed or Planting Stock Availability

Licensed varieties for use in Canada include "Altaswede", "Dollard", "Hungaropoli", "Lakeland", "Lasalle", "Manhardy", "Norlac", "Pacific", "Florei" and "Ottawa" (138). "Altaswede", a late flowering perennial type, is very winter hardy but not particularly drought tolerant and in Alberta is best suited to sites north and west of Edmonton where the average annual precipitation is greater than 42 cm (138). "Norlac" is also adapted to Alberta conditions. "Arlington", "Mammoth", "Midland", "Lakeland", "Kenland", "Pennscott", "Kenstar", and "Chesapeake" are available in the US (713). Approximately 275 000 seeds/lb (639).

Methods and Ease of Establishment

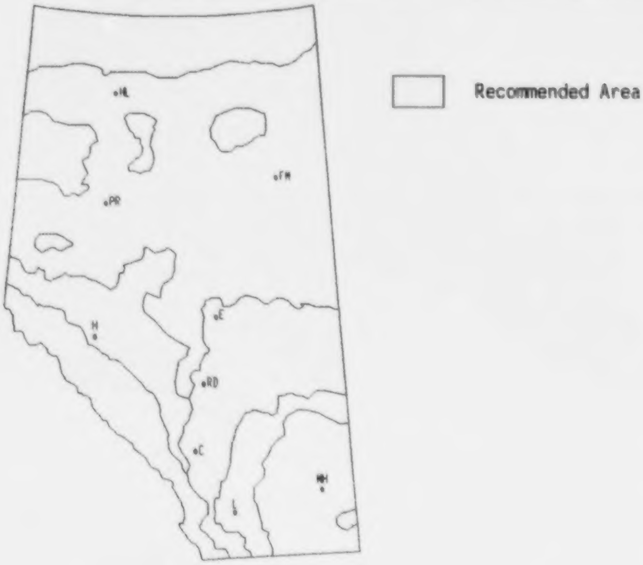
High quality seed should have a purity of 98% and a germination rate of 90% (138). Red clover is readily established because of its high seedling vigour (342). Because it will not normally persist more than 3 years, reseeding is required to maintain production (342). A seeding rate of 10 to 12 lbs PLS/ac has been recommended for the Eastern US (713); 8 to 10 lbs PLS/ac in spring/fall for the west (639).

Current Status for Reclamation

Red clover is a widely used forage species throughout much of North America. It is commonly used for roadside revegetation, and is a common component of reclamation seed mixtures. "Altaswede" dominated grass - legume seedings for three years on the reclaimed Judy Creek test coal mine in northwest Alberta (646). Red clover planted at exploration sites above treeline in northeastern B.C. fared well but only in sheltered, moist pockets (70). Red clover has only fair drought tolerance, is not as sensitive to low soil pH as alfalfa or sweet clover, and can persist in the subalpine for several years. Red clover has been recommended for revegetation of disturbed sites in northeastern Colorado (427). Commonly used for "corridor reclamation" of seismic lines and pipeline rights-of-way in Alberta (P. Sims, pers.comm.).

Trifolium repens

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid			X		
pH Tolerance Base				X	
Winter Hardiness		X			
Erosion Control		X	X		
Persistence			X		
Palatability		X			
Browse Tolerance		X			
Moisture Preference	Moist.				
Soil Preference	Fine to medium textured, moderately well to poorly drained.				

Trifolium repens L.

SPECIES BIOLOGY

Taxonomy - White Clover; Dutch Clover.

Origin and Range

Introduced from Europe. Originated in the eastern Mediterranean countries or in Asia Minor (138). Cultivated in Alaska, and throughout Canada and in the United States (214). Circumboreal distribution (214).

Growth Habit

A low creeping species which often roots at the nodes (690). It has stoloniferous stems (138). White or pinkish flowers (690).

Nitrogen Fixing

White clover fixes atmospheric nitrogen (331) if properly innoculated prior to seeding (500).

Longevity

Long-lived, cool season (713) perennial (78). With good management it may persist for 5 years or more (391). White clover has excellent winter hardiness (240). "Pilgrim" and "Merit" white clover have been developed for winter hardiness (179).

Self Propagation

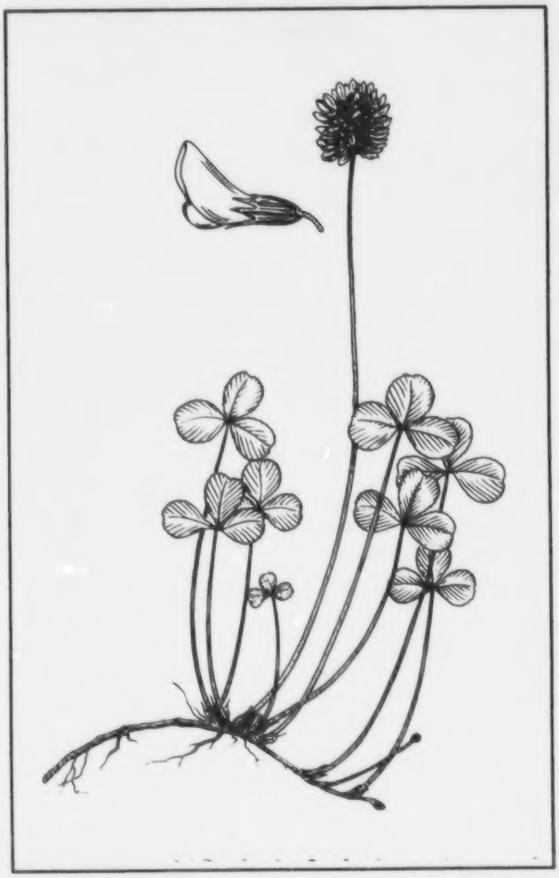
Propagates by seed, as well as spreading by stoloniferous stems (138).

Ecological Setting

It is best adapted to a wide range of altitudes (500). White clover grows best in humid sections of the temperate zone during the cool, moist seasons (138). Commonly used for lawns, this species has escaped from cultivation and is found along roads, in meadows and in wooded areas (78). It is adapted to humid climates (256). Precipitation range is 45 to 114 cm (713); minimum 89 cm (639).

TOLERANCES

Soil Preferences



White clover does best on moist sites (41, 447). It is best adapted to moderately fine to medium textured soils (426) ranging from sandy loam to silty clay loam (5, 256). Soil moisture regime ranges from well or moderately well drained to poorly drained soils that are waterlogged, although there is some doubt regarding the ability of this species to withstand flooding (5). The optimum slope is 0 to 8% and it prefers deep soils. Periods of prolonged high temperatures with either high or low rainfall are unfavourable for growth (138).

Nutrient Requirements

White clover can be readily established in areas of low fertility (342) although it has been rated as having moderate fertility requirements (500). "Ladino" white clover requires high applications of phosphate fertilizer to obtain high forage production (179). Phosphorus and calcium levels are critical (713).

Soil Reaction

White clover is not as sensitive to low soil pH as alfalfa (Medicago spp.) and sweet clover (Melilotus spp.), or as tolerant of low pH as birdsfoot trefoil (Lotus corniculatus) (27). It has poor acidity tolerance (5); lower limit is 5.5 (713). "Ladino" white clover is tolerant of slightly acidic to slightly alkaline soils (179).

Soil Salinity

White clover is not tolerant of saline soil (500). Tolerance limits have been reported at less than 4 mS/cm (247).

Drought

White clover has fair drought tolerance (5), although when white clover was seeded as part of a mix designed for drought-prone soils it did not perform well (77).

Heavy Metals and Hydrocarbons

In sand-culture experiments, additions of 320 ppm Cu, 3 000 ppm Pb or 4 000 ppm Zn resulted in an 80 to 90% reduction in dry weight of white clover (221). White clover has medium tolerance to oil (282). It was difficult to establish and had poor growth on ash at Lake Wabamun (696).

Shade - Prefers open situations.

Grazing or Mowing

White clover can withstand close grazing and recovers rapidly (391).

Susceptibility to Disease and Insect Damage

No susceptibilities noted from the literature.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

White clover is a low, spreading legume that forms roots at the stem nodes. It has a shallow root system (138). "Ladino" white clover has a short tap root (less than 40 cm long). Roots and upright stems form at the stolon nodes, but these roots are short. This growth habit makes white clover well suited to shallow soils. The effective root zone of mature "Ladino" white clover plants is not more than 50 cm (179).

Adaptation to Disturbance

White clover is a pioneer on Alberta mine spoils (331).

Competitive Ability

It is a moderately aggressive species (500).

Commercial Value

Different cultivars are used for forage, turf (sod), and erosion control (426). White clover-grass mixtures are used for hay and silage.

Palatability and Nutritive Value

White clover is highly nutritious and palatable to cattle (256). Yield potential is low (5). It is one of the more nutritious and palatable legumes (138). Forage value has been rated as good for mule deer, game birds and small mammals (447). Causes bloat (639).

Seed or Planting Stock Availability

Certified licensed seed of "Ladino", "Merit" and "Pilgrim" varieties is available through the seed trade (138, 713). Approximately 850 000 seeds/lb (639).

Methods and Ease of Establishment

White clover seed can apparently be stored for long periods. Seed stored for 25 years in unheated sheds had a germination rate of 73%, compared to 88% in the year of collection (211). Typical purity/germination is 99/85% (132). White clover can be established more easily on poorly prepared seedbeds than other legumes (342). Seedling vigour has been rated as fair to poor (41). A seeding rate of 1 to 5 lbs PLS/ac has been recommended for the Eastern US (713); spring/fall seeding at a rate of 2 to 6 lbs PLS/ac for the west (639).

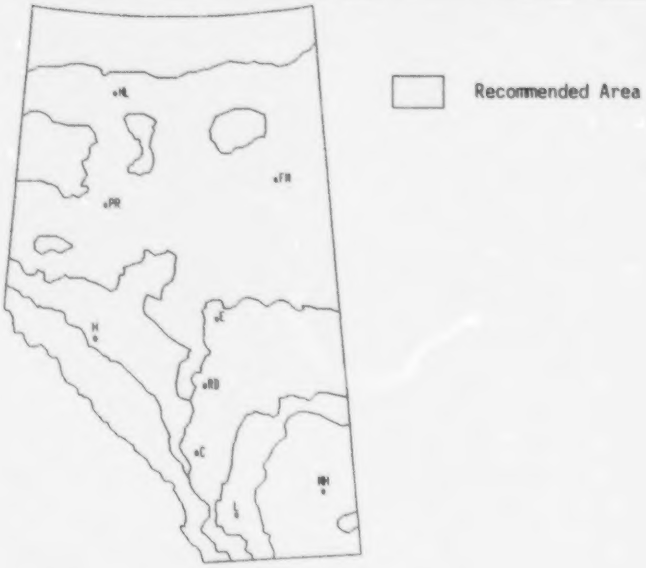
Current Status for Reclamation

White clover is widely used for pasture, hay and silage. It is a common component of reclamation mixes throughout the moister parts of western Canada. Commonly used for "corridor reclamation" of seismic lines and pipeline rights-of-way in Alberta (P. Sims, pers.comm.). It has been used to successfully revegetate acid (pH 4.0 to 5.0) coal mine wastes in New Brunswick (2). White clover had good performance when seeded on disturbed sites above 1 650 m ASL in southeastern B.C. (494). It was a failure in mix trials in subalpine Alberta (705) and winterkilled the first winter in tests in the Upper Mackenzie region of the boreal forest (latitude 63° N) (644). White clover gave poor results when seeded in the alpine in Colorado (164). It was difficult to establish (like most legumes) but performed well on moist sites at 3 530 m ASL in Colorado (236, 73, 462).

White clover is a long-lived perennial clover that spreads by rhizomatous stems; it also fixes nitrogen. In general, it has only fair drought tolerance and is best suited to moist sites. The varieties "Pilgrim" and "Merit" have excellent winter hardiness and should be suited for revegetation planting in Alberta to the lower subalpine.

Vicia americana

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING			
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Acid				X	
Tolerance Base				X	
Winter Hardiness		X			
Erosion Control			X		
Persistence			X		
Palatability		X	X		
Browse Tolerance				X	
Moisture Preference	Moist.				
Soil Preference	Clay loam to sandy.				

Vicia americana Muhl.

SPECIES BIOLOGY

Taxonomy - Wild Vetch

Includes: V. sparifolia Nutt.

Origin and Range

Native. Yukon east across Canada to Hudson Bay; Ontario south to Pennsylvania. South in the mountains to California (214). Wild vetch is highly variable.

Growth Habit

A perennial herb with stems 30 to 100 cm long. Trailing or climbing plant (78, 690). Flowers reddish purple, drying bluish (690).

Nitrogen Fixing

Expected to fix nitrogen as it is a legume.

Longevity - A perennial.

Self Propagation - By seed.

Ecological Setting

Wild vetch is found in open woods and thickets throughout Alberta. Also found at the edges of bluffs and in shady areas of the prairies (78, 690). It ranges from plains to open woods, and meadows of the subalpine (185). Found at between 925 and 2 675 m ASL in moist situations in Wyoming (18). In the southwestern portion of its range, it is common in pine forests at elevations of 1 600 to 3 300 m ASL (426).

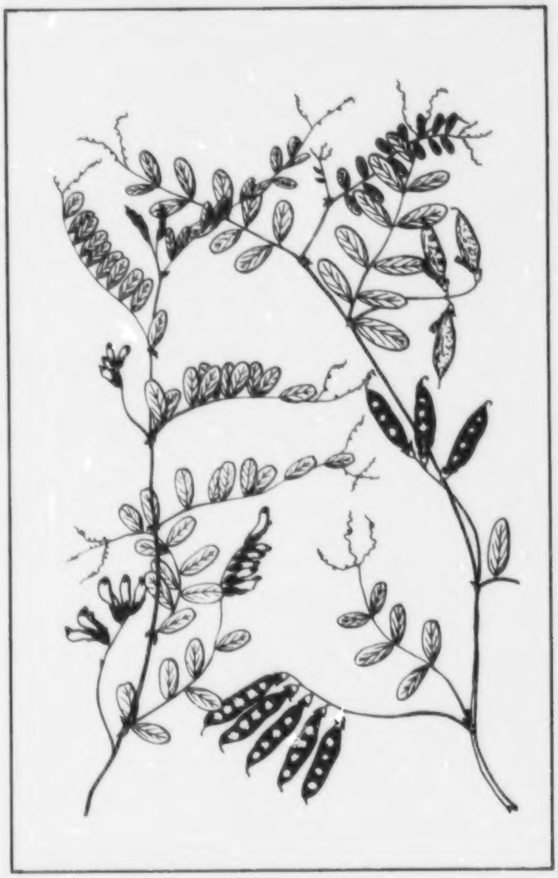
TOLERANCES

Soil Preferences

Wild vetch generally occurs in favourable moisture situations (12, 426). Growth has been reported as fair on sandy and clayey soils, and good on loam soil (146).

Nutrient Requirements

Wild vetch is generally found on favourable fertility sites (12).



Soil Reaction

Prefers neutral soils, but will tolerate mildly acidic to mildly alkaline soils as well.

Soil Salinity

Found on mildly saline soils.

Drought

Favours moist sites. Will not tolerate excessive drought.

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Found on fully shaded sites.

Grazing or Mowing

Wild vetch is found on ranges in good condition but decreases under grazing (426). This may be due to preferential grazing rather than low tolerance.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The creeping growth form and nitrogen fixing ability make this species a good soil builder.

Adaptation to Disturbance

Will invade disturbed sites in adapted area. Found on roadsides.

Competitive Ability

Very aggressive growth form, often choking out other species.

Commercial Value

No known commercial value, besides nitrogen fixation abilities.

Palatability and Nutritive Value

Wild vetch has been described as an excellent forage plant that is palatable to both livestock and wildlife (426). Wild vetch is reported to be lightly browsed by mule deer (245). It has been noted as providing good forage value for mule deer, game birds and small mammals (229).

Seed or Planting Stock Availability

Commercial availability not known.

Methods and Ease of Establishment

Seeds are easily collected. Establishment only by seed. Planting in northwestern Colorado is only recommended on soils deeper than 65 cm (446).

Current Status for Reclamation

Wild vetch has been used successfully for revegetation of alpine tundra disturbances in British Columbia (185) and in hydroseeding trials on mined land at Luscar, Alberta (144, 209). A hydroseeding trial of wild vetch on oil sand tailings in northern Alberta was unsuccessful (257). It has been recommended for revegetation in northwestern Colorado.

SPECIES INFORMATION - SHRUBS AND TREES

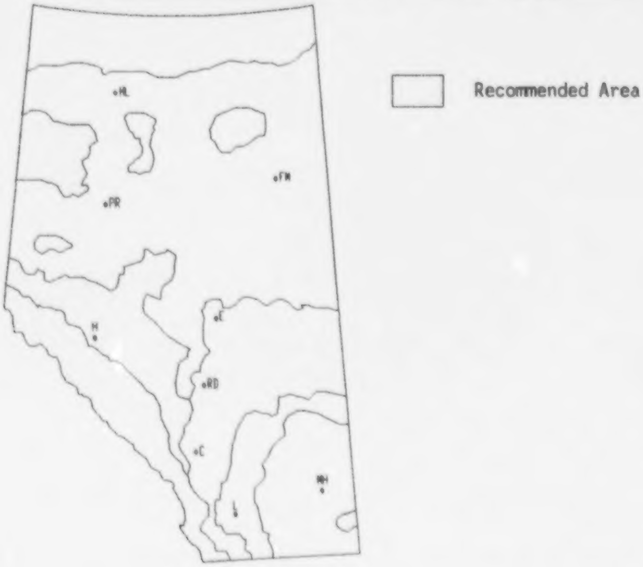
Table 4 Combined performance chart - trees and shrubs

Species	Reclamation Suitability Criteria							
	Drought Tolerance	Salt Tolerance	Winter Hardiness	Soil Reaction Tolerance		Erosion Control	Persistence	Palatability
				Acid	Base			
Abies lasiocarpa	L	L	H	H	U	M	H	M
Acer negundo	L	L-N	M	L	U	M	H	L
Alnus crispa	L	L	VH	M	M	M	H	M
Alnus sinuata	L	L	VH	M	U	H	H	L
Alnus tenuifolia	M	N	H	VH	L	H	H	H-M
Amelanchier alnifolia	H	U	M	M	M	M	H	H-M
Arctostaphylos rubra	M	U	H	H	M	L	H	M
Arctostaphylos uva-ursi	H	L-N	H	M	U	L	H	L
Betula papyrifera	H	L	H	H	U	M	H	M
Ceanothus velutinus	M	U	H	M	U	H	H	H-L
Cornus stolonifera	L	N	H	M	M	M-L	H	H-M
Dryas drummondii	H	N	VH	L	M	VH-H	VH-H	N
Dryas octopetala	H	L	VH	L	M-L	H	M	N
Elaeagnus commutata	M-L	M	H	M	M	H-M	H	L
Juniperus communis	M	L	H	H	L	L	H	L-N
Juniperus horizontalis	VH-H	L	H	H	H	M	H	H-M
Larix laricina	L	L	H	M	L	M-L	H	N
Picea glauca	M	N	H	H	U	L	H	H
Pinus banksiana	M	N	H	VH	M	M	H	M
Pinus contorta	H	L	H	H	M	H-M	H	M-L
Populus balsamifera	L	M	H	L	M	M	H	H-M
Populus tremuloides	M	L	H	L	M	H	VH-H	H-M
Potentilla fruticosa	M	L	H	H	M	M	H	L
Prunus virginiana	M	M	M	M	M	H	H	M
Rosa acicularis	M	L	H	H	U	M	H	H
Rosa woodsii	M	L	H	M	M	H-M	H	H-M
Rubus idaeus	H-M	M	H	M	U	M	H	M-L
Salix arctica	M	L	VH	U	M	L	H	M
Salix bebbiana	L	M	M	M	M	M	H	H
Salix glauca	L	L	H	M	U	M	H	H
Salix scouleriana	M-L	M	H	H	U	M	H	H
Shepherdia canadensis	M	M	H-M	M	M	M	H	L
Spiraea betulifolia	L	M	H	L	L	M	H	L
Symphoricarpos albus	M	M	H	L	M	M	H	H-M
Symphoricarpos occidentalis	M	M	H	L	M	M	H	H-M

VH - very high
H - high
M - medium
L - low
N - none
U - unknown

Abies lasiocarpa

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance					X	
Salt Tolerance					X	
pH Tolerance	Acid		X			
	Base					
Winter Hardiness			X			
Erosion Control				X		
Persistence			X			
Palatability				X		
Browse Tolerance				X		
Moisture Preference		Moist to dry.				
Soil Preference		Wide variety - loamy soils, tolerates wide range.				

Abies lasiocarpa (Hook.) Nutt.

SPECIES BIOLOGY

Taxonomy - Alpine Fir

Origin and Range

Native. Southeast Alaska, central Yukon Territory, south through British Columbia and southwestern Alberta and in the mountains to New Mexico, Arizona and Oregon (443). In Alberta, alpine fir extends eastward from the mountains to Pigeon Lake and Whitecourt in central Alberta. It probably intergrades with A. balsamea in the region of Lesser Slave Lake and the Athabasca River (690, 205).

Growth Habit

Usually a small or medium sized tree (443). Alpine fir may be up to 30 m high and 70 cm in diameter (443, 205). At timberline it is reduced to a prostrate shrub that may be very thick as a result of rooting of the lowermost branches (690, 501).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Seed, layering, stolons (5, 437). Natural reseeding capability is better developed than vegetative reproductive means (338).

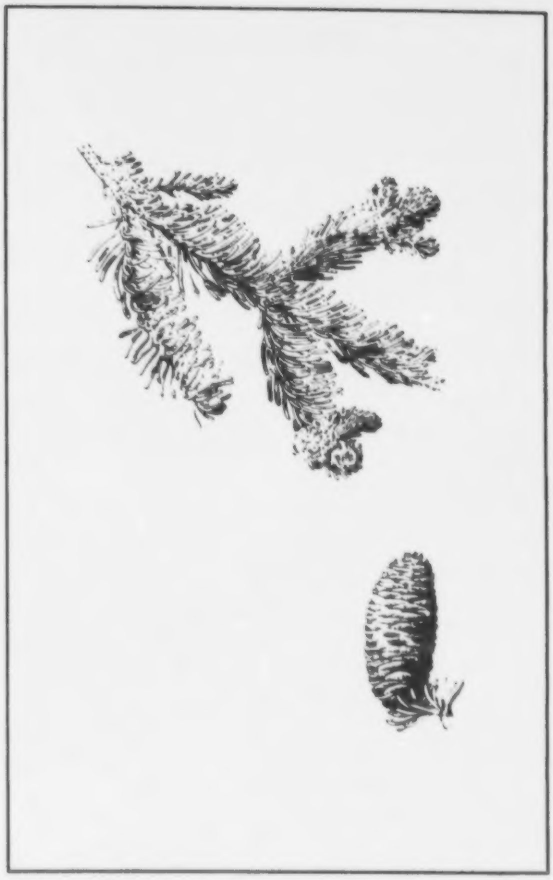
Ecological Setting

Alpine fir is characteristic of subalpine forests and northwestern areas of the boreal forest at elevations ranging from 600 to 2 300 m ASL (205). It is generally found above Engelmann spruce (Picea engelmannii) and is usually associated with cool, moist north and west facing slopes (501). Common native associates are: Picea engelmannii, Pinus contorta var. latifolia, Populus tremuloides, and Larix lyallii (391).

TOLERANCES

Soil Preferences

Alpine fir grows best on well drained loamy soils (205). It is adapted to moderately well drained to well drained soils, and occurs on a wide variety of soil textures (5, 205).



Nutrient Requirements

The ability of alpine fir to grow on infertile soils suggests low nutrient requirements.

Soil Reaction

Alpine fir is reported to have a high acid tolerance (5).

Soil Salinity

No specific information is available, but a fairly low tolerance of saline conditions would be expected.

Drought

Alpine fir grows best on moist sites where risk of drought is low.

Heavy Metals and Hydrocarbons

No information available in the literature reviewed.

Shade

Alpine fir is very shade tolerant (443, 5).

Browsing

Though browsing is not extensive, the species appears to withstand it satisfactorily.

Susceptibility to Disease and Insect Damage

Alpine fir is susceptible to needle rust, needle cast, snow blight, snow mold, needle blight, Armillaria root rot, and white pocket rot (29, 198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Alpine fir has a shallow root system which is widespreading. The tree is not windfirm (205). The species is rated "good" for its ability to stabilize soil (338). At treeline the lower branches may root by layering, resulting in a thick hedge-like shrub, the centre of which is quite often the dead parent tree (501). It has a slow height growth rate and a slow cover rate (5).

Adaptation to Disturbance

The species has a medium adaptation to disturbance (338).

Competitive Ability

At least moderate on suitable sites.

Commercial Value

Used for general construction lumber and pulp (205). Alpine fir is also used for watershed protection, and as an ornamental (419).

Palatability and Nutritive Value

Alpine fir is selectively browsed by elk, moose, deer and snowshoe hare, especially the new growth.

Seed or Planting Stock Availability

Very small quantities of native seed are available at high cost (349).

Methods and Ease of Establishment

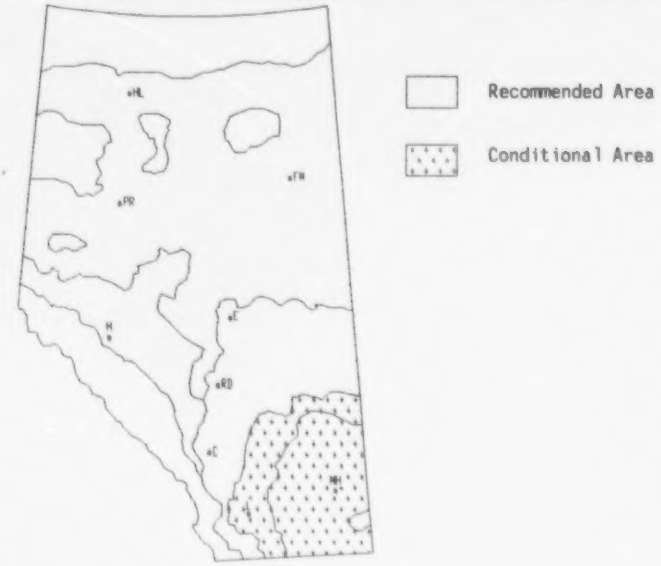
Seed. Interval between seed crops is usually 2 to 3 years (119). Seed germination can be improved by storing cones which are collected early, in cool, moist conditions for several weeks. Seed can be stored for long periods in sealed containers at or near 0°C with a seed moisture content of 9 to 12% (419). Seed has embryo dormancy. Cold stratify at 2 to 9°C for 6 to 8 weeks. Fall sowing is possible. Seed viability varies between 25 and 40% (119). Fir seedlings have slow initial growth and are usually outplanted as 2 to 3 year old seedlings, or as 3 to 4 year old transplants (419). Firs may also be established from cuttings (322).

Current Status for Reclamation

Alpine fir is recommended for revegetation in southeastern Alaska. The maximum spacing for planting seedlings and transplants has been suggested to be 3 m by 3 m (5). Alpine fir has been successfully transplanted using tree digging and planting machines (283).

Acer negunda

SPECIES SUITABILITY MAP AND SUMMARY TABLE


HL
FM
PR
H
C
RD
C
MH
▭ Recommended Area
▨ Conditional Area

Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	X
pH Tolerance Acid				X	
Base					
Winter Hardiness			X		
Erosion Control			X		
Persistence		X			
Palatability				X	
Browse Tolerance			X		
Moisture Preference	Moist.				
Soil Preference	Loamy to clay, well to imperfectly drained.				

Acer negundo L.

SPECIES BIOLOGY

Taxonomy - Manitoba Maple, Box Elder

Origin and Range

Native. Throughout the southern prairie provinces and most of the United States (419). It has been widely planted and has established itself beyond its natural range (205).

Growth Habit

Manitoba maple is a small to medium sized tree, 13 m to 16 m in height and 0.3 m to 0.6 m in diameter. It may occasionally reach heights of 34 m (205). Manitoba maple may be shrub-like if precipitation is inadequate for good growth (159).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Manitoba maple is a dioecious species, and reproduction is by seed (205, 419).

Ecological Setting

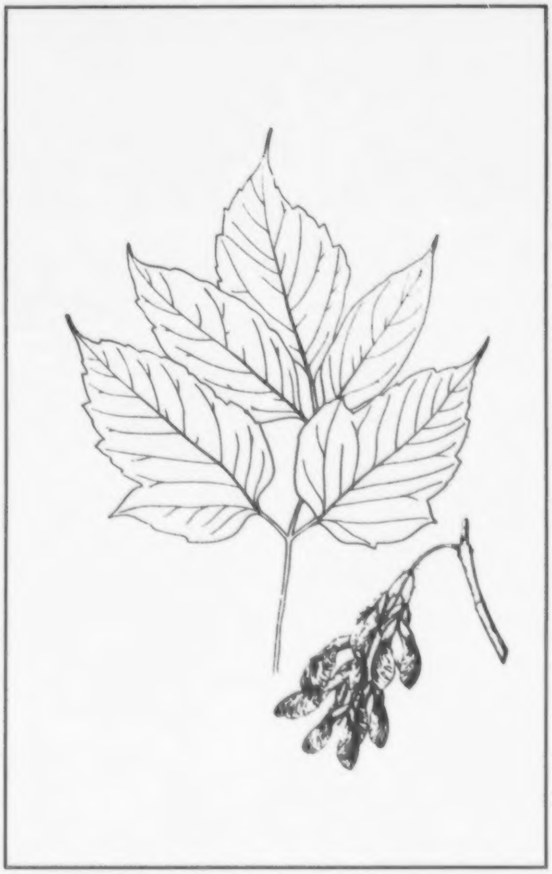
Manitoba maple is usually found along banks of streams and wooded valleys in central and southern Alberta. Widely planted as an ornamental and for shelterbelts throughout the prairies (205). Manitoba maple is characteristic of hardwood draws in North Dakota. These are usually moist sites in the break areas of major rivers (265). Considered to be very cold tolerant (608).

TOLERANCES

Soil Preferences

Soil preferences are observed to be fairly broad, ranging from well to imperfectly drained sites, and clayey and loamy soils.

Nutrient Requirements



Sites where Manitoba maple is naturally found suggest moderate nutrient requirements.

Soil Reaction

Survival of Manitoba maple planted on acid (pH below 4.5) mine spoils, low in phosphorus was very low (21%) in trials in eastern Kentucky (335). Probably favours slightly acid conditions.

Soil Salinity

Manitoba maple is rather intolerant of saline soils (229).

Drought

Manitoba maple is not very drought tolerant. Trees planted in trials at Saskatchewan Landing, Saskatchewan, suffered top-dieback during drought years.

Heavy Metals and Hydrocarbons

No information located in the literature reviewed.

Shade

Manitoba maple appears to be relatively shade intolerant.

Browsing

Infrequently browsed, therefore tolerances to browsing are not known. The species resprouts well after cutting however.

Susceptibility to Disease and Insect Damage

Manitoba maple is susceptible to large leaf spot, powdery mildew, leaf spot, tar spot, white ring spot, and white spongy rot (198). The seedlings are susceptible to "damping-off" (419).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The species is considered a good soil stabilizer (338).

Adaptation to Disturbance

Manitoba maple is a seral species on floodplains in North Dakota (265). Its adaptation to disturbance is considered "medium" (338).

Competitive Ability

Presumed to be moderate.

Commercial Value

The wood of Manitoba maple is used for boxes and rough construction lumber. Manitoba maple is also widely planted as an ornamental and in shelter belts (205, 222).

Palatability and Nutritive Value

Manitoba maple appears to be avoided by wildlife, suggesting low palatability.

Seed or Planting Stock Availability

Seed and containerized seedlings are fairly readily available.

Methods and Ease of Establishment

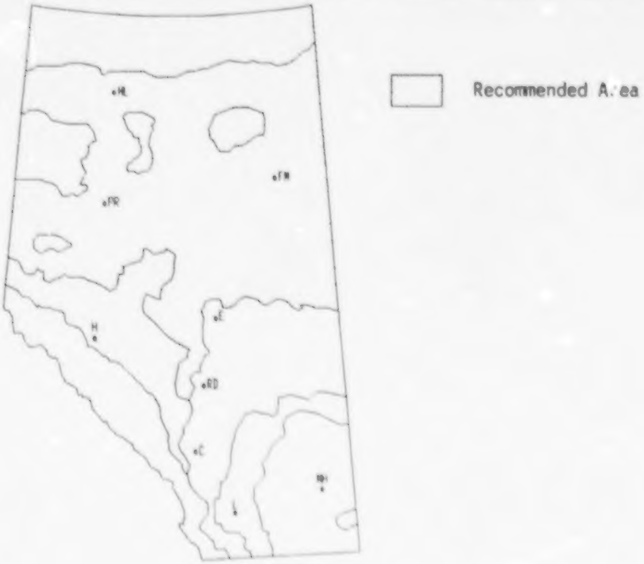
Seed requires warm stratification for 180 days, followed by cold stratification for 180 days. Manitoba maple has a hard pericarp which should be mechanically ruptured before stratification. Treatment of the seed with either boric acid or hydrogen peroxide has aided germination. Best results are obtained when seeds are sown in mulched beds in the fall. Shade will aid in seedling establishment (419). Rocky mountain maple can be established with difficulty from seed, by transplanting and stem cuttings. The recommended spacing is approximately 2.5 m by 2.5 m (174). On heavy soils, the spacing requirement was calculated to be 6 m by 6 m, and on light soils 9 m by 9 m (222). Manitoba maple is one of several trees and shrubs recommended for the construction of "hedges" from unrooted cuttings. These cuttings are planted in wedge-shaped trenches across steep slopes and the resulting hedge stabilizes the slope (325).

Current Status for Reclamation

Manitoba maple is recommended for plantations in southern Alberta and Saskatchewan on sites with sufficient moisture. Survival in tests on alpine and subalpine sites in Alberta was very poor (671, 707). At Fort McMurray survival on amended tailings sand was high after seven years, however the plantings suffered heavy annual dieback (706). Manitoba maple is used in reclamation in Germany (331).

Alnus crispa

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Acid			5.5		
Tolerance Base			8.0		
Winter Hardiness	X				
Erosion Control			X		
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Moist to wet, tolerates seasonal flooding and flowing water.				
Soil Preference	Sandy loam to silty clay loam.				

Alnus crispa (Ait.) Pursh.

SPECIES BIOLOGY

Taxonomy - Green Alder

Subspecies: ssp. crispa and ssp. sinuata (Regel) Hult.

Origin and Range

Native. Alaska and the Yukon Territory to Labrador, Newfoundland and Greenland, south to New York, North Carolina (in mountains), Michigan and Oregon. Also across northern Asia. This species intergrades with sitka alder (Alnus sitchensis) towards the southern coast of Alaska (443). Some authors regard sitka alder as a subspecies of A. crispa (443).

Growth Habit

Shrub 1 to 5 m high. Deciduous. Often forms dense thickets (312).

Nitrogen Fixing

Fixes atmospheric nitrogen. Associated with the N_2-fixing actinomycete Frankia and the basidiomycete Alpova diplophloeus (622).

Longevity - Long-lived perennial.

Self Propagation - Seed.

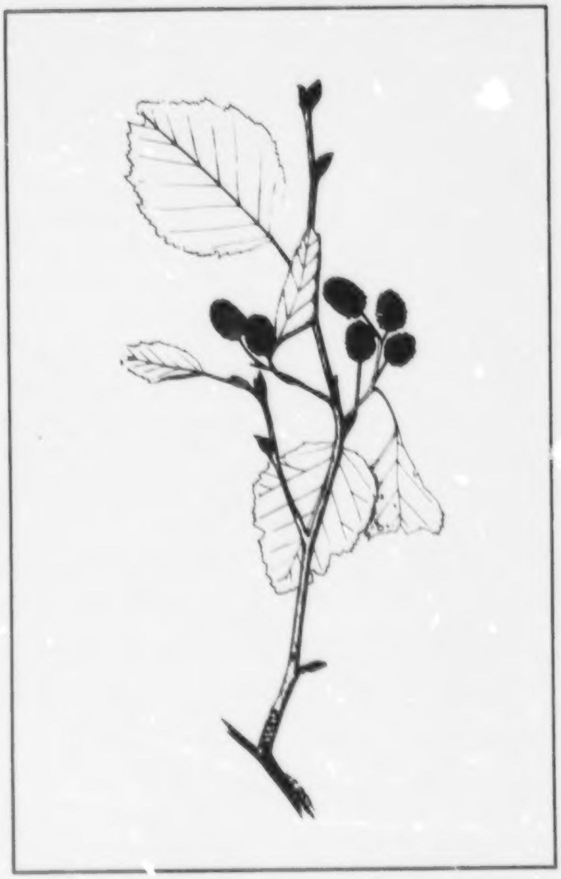
Ecological Setting

Common in central and northern Alberta. Throughout the latitudinal range of the eastern slopes. Sandhills, open woods, borders of bogs, and along stream channels. Disturbed sites and floodplains. Extends above snowline along creek beds or scree slopes subject to avalanches (501). Common native associates (mixed-wood): Pinus banksiana, Picea glauca, Populus tremuloides, Vaccinium myrtilloides, Viburnum edule, Rosa acicularis (443, 312).

TOLERANCES

Soil Preferences

Adapted to a range of soil moisture conditions from well drained through to poorly drained. Found on a range of soil textures from sandy loam to silty clay loam (5). Alnus crispa ssp. crispa reported to be capable of growing in up to 20 cm of flowing water during the peak spring run-off in the Mackenzie River delta area (97).



Nutrient Requirements

Observed on nutrient deficient sites in Alberta (306).

Soil Reaction

High acid tolerance (5). The growth of alder planted on a sandy soil (pH 5.5) was reduced by the addition of lime (154). However green alder is often a pioneer on alkaline glacial outwash (pH 8.0) (105). The closely related A. viridis is a continental alpine species that occurs naturally on soils from acid rocks and has been described as an acidophile. However, good growth has been reported for A. viridis in soil where their roots overlie chalk (405).

Soil Salinity

Salinity tolerance not known, but presumed to be minimal.

Drought

Alder is generally not very drought tolerant (495).

Heavy Metals and Hydrocarbons

Green alder showed good recovery 2 to 3 years after summer and winter crude oil spills near Norman Wells, N.W.T. On the mature forest taiga sites, green alder was reported to be vigorous and root nodules were common (216). Unaffected by a winter methanol spill near Inuvik, N.W.T. (487). Green alder is sensitive to high soil copper concentrations. Nodule production was completely inhibited at copper concentrations above 100 ppm (154).

Shade - Low shade tolerance (5, 172).

Browsing

Resprouts rapidly after cutting (5). Could be expected to withstand moderate browsing well.

Susceptibility to Disease and Insect Damage

Susceptible to powdery mildew, leaf blister, white rot (198). Susceptible to insects such as alder fly beetle, poplar and willow borer, striped alder sawfly, and western tent caterpillar (P. King, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Rapid cover rate (5). In general, alders have shallow root systems (365). Successfully used for slope stabilization near Norman Wells, N.W.T. (110). The fertility and physical properties of soil are improved by all species of alder (176).

Adaptation to Disturbance

Will resprout from stumps if killed by fire or cut (5). One of the early plants to reinvade burned dry tundra (sandy soil) near Inuvik, N.W.T. (458). Reported to be a pioneer on seismic lines in the Mackenzie Delta, N.W.T. (194) and in Alberta (P. Sims, pers.comm.). Observed on eroding slopes in Alberta (277).

Competitive Ability

Judging by its growth in natural stands, green alder is thought to be relatively aggressive.

Commercial Value

Twigs and buds are winter food for white-tailed ptarmigan (443); potential use as nursery crop for timber production (172).

Palatability and Nutritive Value

Component of winter diet of moose on the Kenai Peninsula, Alaska (255). Some use by mule deer (245).

Seed or Planting Stock Availability

Native seed is available at moderate cost (349).

Methods and Ease of Establishment

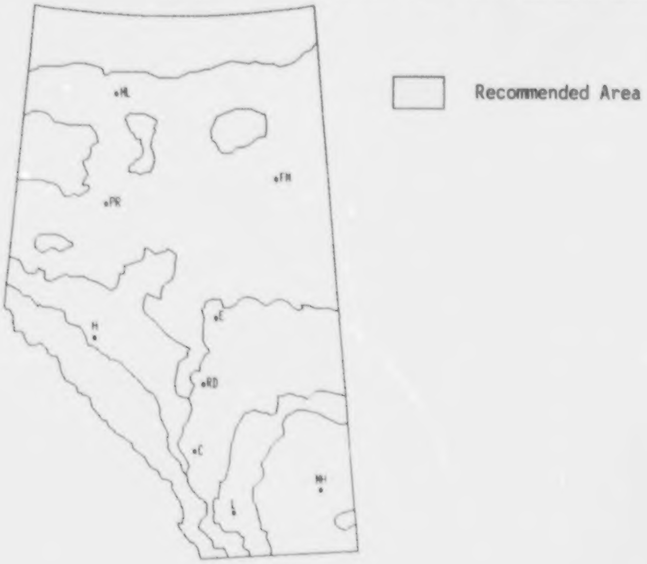
Seed embryo dormancy encountered in some seed lots (419). Seed can be stratified at 1 to 5°C for 60 days (419). Spring sow non-dormant seed; fall sow dormant seed (21). Propagation by 0.3 m hardwood cuttings is also possible (21). Greenhouse trials indicate germination rates of 17 to 18% for seed collected near Fort McMurray, Alberta (149). Green alder may be germinated without stratification, however, stratification accelerates germination (495). Use of seed or seedlings and transplants (maximum spacing of 1.5 m by 1.5 m) is recommended for propagation of green alder in Alaska (5).

Current Status for Reclamation

Survival on amended tailings sand at Fort McMurray is generally poor, 50% or less after 5 years is typical; however, growth of survivors is rated as good (641, 705). Eighth year survival on a subalpine site in Alberta (Tent Mountain) was high (78%), suggesting that green alder has potential for reclamation on protected subalpine sites; however, growth and development may be limited by browsing. Green alder is noted for its ability to colonize tailings at the Discovery Mine, N.W.T. (49). A fall planting of hardwood cuttings on an unstable, water-saturated, gravelly slope near Norman Wells, N.W.T. had excellent first year survival (100%). Spring planting of 1 m cuttings gave very good survival as well (78 to 100%) (110). Recommended for revegetation planting in interior Alaska (5).

__Alnus sinuata__

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid			X		
Base					
Winter Hardiness	X				
Erosion Control		X			
Persistence		X			
Palatability				X	X
Browse Tolerance		X			
Moisture Preference	Moist to wet.				
Soil Preference	Wide range of textures, well drained to waterlogged.				

Alnus sinuata (Reg.) Rydb.

SPECIES BIOLOGY

Taxonomy

Sitka Alder (205); Mountain Alder; Wavyleaf Alder (419).

Also A. sitchensis (Reg.) Sarg., A. fruticosa Rupr. var. sinuata (Reg.) Hult. (443).

Origin and Range

Native. Yukon and Alaska southeast to southwestern Alberta, western Montana and northern California. Also in northeastern Asia (443). Intergrades with American green alder (Alnus crispa (Ait.) Pursh) in Alaska (443). Regarded as geographic variation of Alnus crispa (Ait.) Pursh, by some authors. Under that classification, Sitka alder is a subspecies with the name Alnus crispa (Ait.) Pursh ssp. sinuata (Reg.) Hulten (205). In southeastern B.C. occurs only above 1 000 m (120).

Growth Habit

Deciduous shrub 1.5 to 4.5 m high; on favourable sites it may reach tree size of up to 9 m with a diameter of 20 cm (443, 205). Often forms dense thickets (312).

Nitrogen Fixing

Fixes atmospheric nitrogen (120) on the recessional moraines of the Herbett and Mendenhall Glaciers in southeastern Alaska. Nitrogen accumulated at a rate of 4.0 $g/m^2/yr$ in the leaf litter and mineral soil over 10 to 60 years. The decline in the rate of nitrogen accumulation at 60 to 70 years paralleled a similar decline in the dominance of alder in the forest stand (104). The positive effects of sitka alder nitrogen content on avalanche debris have been noted after 5 years.

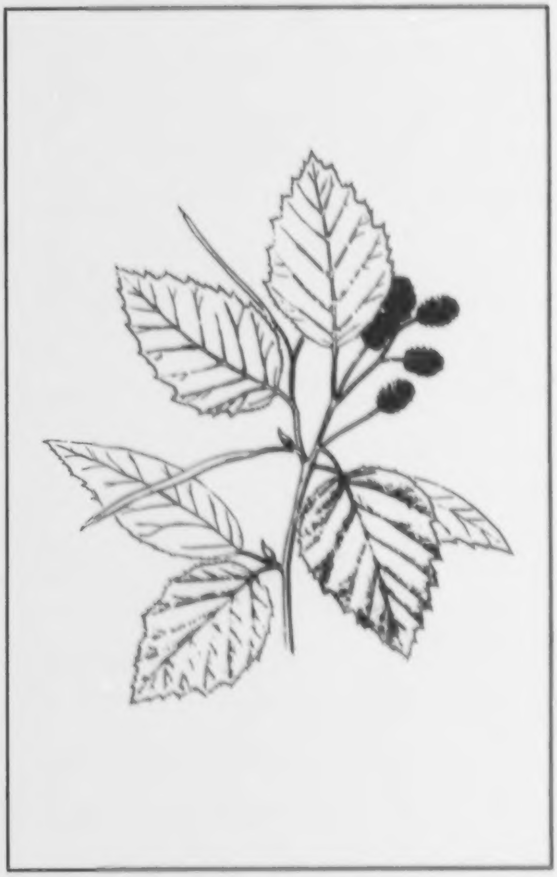
Longevity - Long-lived perennial.

Self Propagation

Seed. Resprouts from stumps after fire (5).

Ecological Setting

Found in cool and moist situations at both high and low elevations (205). Forms thickets along streams, and in clearings from sea level to the alpine in Alaska (443). Pioneer species which follows disturbances such as landslides, snowslides, logging or glacial retreat (443). It is common in moist woods and on open slopes in southwestern Alberta, often forming thickets on mountain slopes (312).



TOLERANCES

Soil Preferences

Adapted to soils that are well, moderately well, or poorly drained and waterlogged (5). Found on a wide range of soil textures (5). Reported to require a mineral soil seedbed and to develop rapidly on moist sites (443).

Nutrient Requirements

Apparently grows on soils too sterile for other trees (443).

Soil Reaction

Moderate acid tolerance (5).

Soil Salinity

Specific tolerance levels not found in literature reviewed. Suspected to be relatively intolerant.

Drought

Appears from its site preferences to be susceptible to drought.

Heavy Metals and Hydrocarbons

Suspected to be relatively tolerant to oil spills.

Shade

Low shade tolerance (5). Reported to thrive in direct light but disappears from stands once overtopped by sitka spruce (443).

Browsing

Expected to recover fairly quickly by resprouting.

Susceptibility to Disease and Insect Damage

No specific susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Has rapid cover rate (5, 205, 312). It is a spreading shrub (205) that often forms extensive, dense thickets. Regarded as a nurse tree, building soil by adding nitrogen and organic matter. Has abundant leaf fall and its habit is effective in trapping the leaf litter of other plant species. The decomposition of this litter greatly increased soil acidity at Glacier Bay, Alaska; the pH of the uppermost soil horizons under alder was reduced from 8.0 to 5.0 within 35 to 60 years (105). In Alaska, the rate of accumulation of above-surface organic residues under alder is reported at 5 to 6 kg/m^2, 6 to 7 cm deep, within 40 to 50 years (105). Calcium carbonate under alder declined from 5% to zero in the first 35 to 50 years (105).

Adaptation to Disturbance

Alnus crispa subsp. sinuata reported to invade the recessional moraines of glaciers in southeastern Alaska (104). Invaded moist mine tailing slopes at 1 340 m ASL in southeastern B.C. (96). Pioneer on coal mine spoil at Cadomin, Alberta (1 675 m ASL) where severe climatic limitations were evident (wind, drought) (257).

Competitive Ability

Because it is intolerant of shade and smaller than red alder, sitka alder is readily overtopped and outcompeted by red alder on logged areas in Alaska (443).

Commercial Value

Erosion control (120), and soil building.

Palatability and Nutritive Value

Some use by mule deer in winter and summer (245). Generally avoided by moose and elk.

Seed or Planting Stock Availability

Native seed is available commercially.

Methods and Ease of Establishment

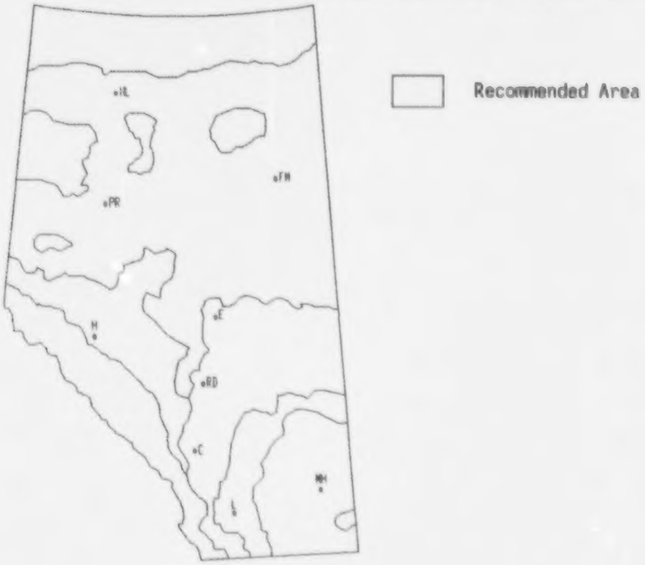
Yearly seedcrops (419). Seeding is the recommended method of establishment (5). Seed of closely related Alnus crispa usually does not require stratification; occasional dormant lots can be stratified at 1 to 5°C for 30 to 60 days (419). Fall sow dormant seed or stratify. Spring sow non-dormant seed (21). Seed should not be allowed to dry below 10% moisture content (419). Alnus spp. may also be propagated from 0.3 m hardwood cuttings (21, 120).

Current Status for Reclamation

Sitka alder has been recommended for revegetation in southeastern Alaska on well drained through to wet sites (5). This species is restricted to cool moist situations in the foothills and mountains of southwestern Alberta. It is a pioneer on recently disturbed or nutrient poor soils and spreads rapidly, forming dense thickets. Sitka alder has potential use for erosion control and reclamation, particularly on poor soils where its ability to fix atmospheric nitrogen is a valuable asset. Further research is needed into the best methods of establishment and early management.

Alnus tenuifolia

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance				X		
Salt Tolerance						X
pH Tolerance	Acid	3.5	X			
	Base				X	
Winter Hardiness			X			
Erosion Control			X			
Persistence			X			
Palatability			X	X		
Browse Tolerance				X		
Moisture Preference		Moist to wet, tolerates flooding.				
Soil Preference		Wide range of textures, well to poorly drained.				

Alnus tenuifolia Nutt.

SPECIES BIOLOGY

Taxonomy - River Alder; Mountain Alder (608).

Also *Alnus incana* (L.) Moench ssp. *tenuifolia* (Nutt.) Breitung, *A. rugosa* (Du Roi.) Spreng.

Origin and Range

River alder is often treated as a variety or subspecies of the Eurasian species *A. incana* (L.) Moench (European speckled alder). It is also closely related to speckled alder (*A. rugosa* (Du Roi.) Spreng) which replaces it from Saskatchewan eastward. It occurs from Alaska and the Yukon Territory, southeast through British Columbia and Alberta to southwestern Saskatchewan. It also is found south in the mountains to New Mexico and California (443, 205).

Growth Habit

A large shrub or small tree, 2 to 8 m high (443); up to 9 m (608). On the best sites may reach up to 15 m high with a diameter of 27 cm (205). Commonly forms large clumps. Fast growing (608).

Nitrogen Fixing

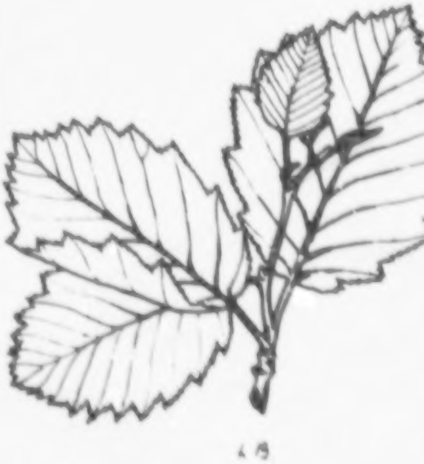
Fixes atmospheric nitrogen (331, 120). Nitrogen was reported to accumulate at an average rate of 156.4 kg/ha/yr in 20 year old alder (*Alnus incana* (L.) Moench. ssp. *tenuifolia* (Nutt.) Breitung) stands near Fairbanks, Alaska (90).

Longevity - Long-lived perennial.

Self Propagation - Seed (5).

Ecological Setting

Borders of streams and lakes (312); preference for wet sites (608). Closely related speckled alder reported to grow best in relatively wet situations, in gullies and swamps that have some drainage (205). Found in western part of Canadian prairies. More common as species of mountain to subalpine zones (331). In northern Alberta, characteristically found along wet but freely drained depressions and river bottom lands (399). Common native associates: *Populus balsamifera*, *Cornus stolonifera*, *Viburnum edule*, *Salix bebbiana*.



TOLERANCES

Soil Preferences

Usually found on alluvial and other moist soils (64). Adapted to a range in soil moisture conditions from well drained to poorly drained (5). Found on a wide range of soil textures (5). Can withstand flooding during the growing season (5).

Nutrient Requirements

Occasional pioneer on gravel bars which are low in nutrients (422). More vigorous growth is associated with nutrient rich sites in central Alberta.

Soil Reactions

Moderate acid tolerance (5). Rates of survival of the related *Alnus incana* (L.) Moench. were not related to soil acidity (pH 3.4 to 7.7) for five year old plants on Ohio spoil banks (262). Speckled alder has been noted on spoil banks of pH 3.5 (291).

Soil Salinity

Not generally found on saline soils.

Drought

Reported as occasional pioneer on drought prone gravel bars in interior Alaska. These sites were also susceptible to rapid freezing and thawing (442).

Heavy Metals and Hydrocarbons

No specific tolerance noted.

Shade - Low shade tolerance (5, 356).

Browsing

If plant cut, will resprout from the stem (5).

Susceptibility to Disease and Insect Damage

Susceptible to powdery mildew, leaf spot, leaf blister, and catkin blister (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Has rapid height growth and rapid cover rate (5). Successfully used for slope stabilization near Norman Wells, N.W.T. (110). The fertility and physical properties of soil are improved by all species of alder (88).

Adaptation to Disturbance

Reported to be a pioneer on Alberta mine spoils (331). Alnus incana and A. tenuifolia sometimes present as pioneers on exposed gravel and silt bars of the Chena River, interior Alaska (442).

Competitive Ability

Alnus incana was reported to have a low rate of survival on Ohio spoil banks due to excessive competition from black locust (Robinia pseudoacacia) and crown-vetch (Coronilla varia) on extremely acid sites (262).

Commercial Value

Large trees have been cut for poles, and the wood has also been used to smoke salmon (443); erosion control (110, 120).

Palatability and Nutritive Value

Moderate use by mule deer in winter and summer (245); high frequency of browse use (31 to 100%), and moderate intensity of browse use by mule deer and elk in southeastern B.C. (393).

Seed or Planting Stock Availability

Native seed is available commercially.

Methods and Ease of Establishment

Seed has been recommended as the best method for establishment (5). A low percentage (less than 5%) of good seed has been reported for some collections, usually in sparse seed crops (419). Germination capacity of fresh seed was reported to be good for stratified and non-stratified seed (419). Air dried seed can be stored in sealed containers at 1 to 3°C (419). Seeds should not be allowed to dry below 10% moisture content (419). Seedlings and transplants should be planted at a maximum spacing of 1.5 m by 1.5 m (5). Also, suited for propagation from 0.3 m hardwood cuttings (21, 120).

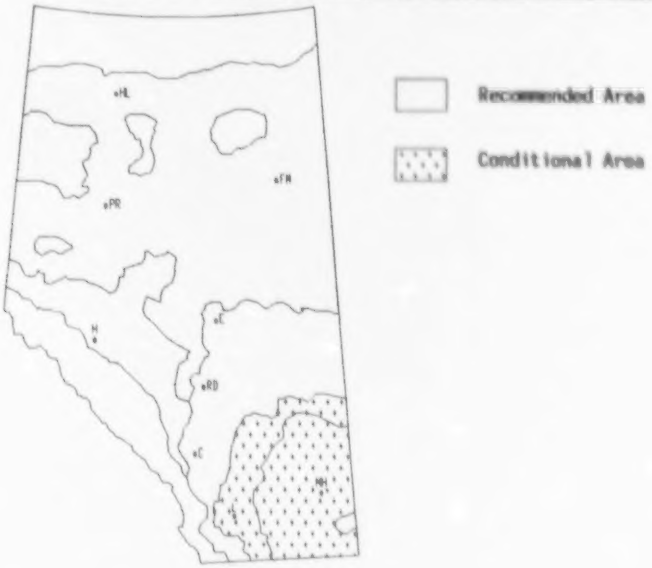
Current Status for Reclamation

A fall planting of hardwood cuttings (Alnus incana) on an unstable, water-saturated, gravelly slope near Norman Wells, N.W.T., had very good first year survival. Spring planting of 1 m cuttings gave similar results (110). Very low survival was found in test plantings on amended tailings sand at Fort McMurray (706). Initial mortality was high (80%) but subsequent mortality was low (14% survival at 8 years) in tests at Tent Mountain (subalpine) in Alberta. Growth of survivors was limited by harsh conditions resulting in heavy dieback and by heavy browsing (707). River alder has been recommended for revegetation in Alaska on well drained to wet sites (5).

Among its attributes, river alder is moderately tolerant of soil acidity and drought. It is fast growing and has the ability to fix atmospheric nitrogen. The closely related species European speckled alder (Alnus incana) is used extensively for mine reclamation in Europe. Mountain alder is considered to be an excellent choice for riparian restoration (608). River alder has potential for reclamation use throughout Alberta but further research is needed into the best method of establishment.

Amelanchier alnifolia

SPECIES SUITABILITY MAP AND SUMMARY TABLE


HL
FM
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Recommended Area
Conditional Area

Commercially Available: Yes_X_ No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance					
pH Acid			X		
Tolerance Base			X		
Winter Hardiness			X		
Erosion Control			X		
Persistence		X			
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Moist to dry.				
Soil Preference	Coarser texture, tolerates wide range.				

Amelanchier alnifolia Nutt.

SPECIES BIOLOGY

Taxonomy - Saskatoon; Serviceberry

Hybrids between the main species of serviceberry (Amelanchier Medic) have been reported (205).

Origin and Range

Native. Southern Yukon and Northwest Territories to Newfoundland with only scattered representation in central Ontario. Distributed south to Oregon and Utah, east to northwestern Iowa (419, 205, 186).

Growth Habit

A shrub or small tree 1 to 6 m in height; many-stemmed, deciduous (78, 312). Low and spreading shrub in the subalpine (501).

Nitrogen Fixing - None

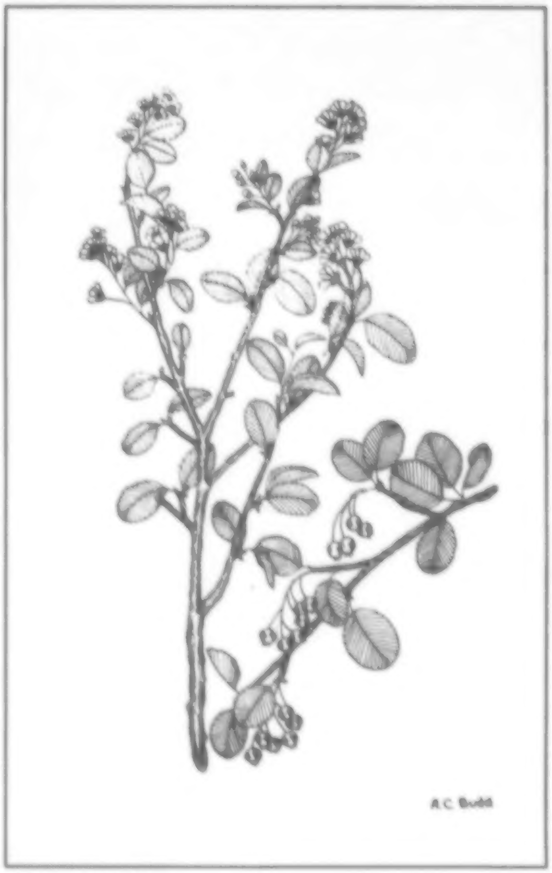
Longevity - Long-lived perennial. Individual stems live up to 70 years, root crowns probably much longer (621, 719).

Self Propagation

Natural cross pollination estimated at 20% (600). By seed. Spreads by stolons to form colonies (690). Produces suckers after burning (604). May form single-clove thickets occupying up to 0.4 ha. Seed dispersal is accidental via birds and mammals (621).

Ecological Setting

Saskatoon is adapted to a wide range of habitats extending from near sea level to the subalpine (200). It is adapted to a wide range of climatic conditions (186), including low temperature extremes (638, 668, 689). Throughout the northern prairie states, it is very common on bluffs and coulees. Usually found on mid to lower slopes when growing in coulees. Throughout the boreal forest, it is largely confined to south-facing bluffs, clearings, open woodlands and road margins. Common native associates: Rosa acicularis, Vaccinium myrtilloides, Linnaea borealis, Alnus crispa, Populus tremuloides (78, 690).



TOLERANCES

Soil Preferences

Found on all types of soil except poorly drained and heavy clay soils lacking in humus (186), prefers coarser textured soils. It is found on well drained drier sites in the northern part of range; it prefers moister situations in southern part of range (426, 443). Best growth on well drained, light textured soil with high organic matter (>3%) content. Addition of peat moss or green manuring may be beneficial (G. Grainger pers. comm.).

Nutrient Requirements

Good survival noted for seedlings planted on road cutbanks and fills in eastern Washington, but seedlings had poor vigour. Fertilizers were suggested to improve effectiveness of growth (415). There is no evidence that fertilizing is beneficial on agricultural soils with normal fertility (G. Grainger pers. comm.)

Soil Reaction

Saskatoon is found on moderately acidic to moderately alkaline soils (338). Adapted to a wide range of soil reaction (689). Best growth on soils with pH range 6.0 to 7.0 (G. Grainger pers. comm.), and can tolerate pH 5.5 to 7.5 (621).

Soil Salinity

No specific tolerances known, but it is not found in saline conditions (621).

Drought

Seedlings have good drought tolerance (303). This is one of the more drought tolerant native shrubs.

Heavy Metals and Hydrocarbons

Considered to have moderate heavy metal tolerance as indicated from observations of its growth near smelters (eg. Trail, B.C.). However, it survived poorly on Cu-Mo tailings (667).

Shade

Appears to be fairly shade tolerant although it prefers open sites. However, the higher humidity resulting from shading, typically when crowded by aspens causes increased disease, progressive weakening and eventually death (621).

Browsing

Can withstand moderate browsing when bush is mature. Hedging occurs on heavily browsed plants.

Susceptibility to Disease and Insect Damage

Saskatoon is susceptible to defoliation by the forest tent caterpillar, northern tent caterpillar and the tortrix. Gall damage to foliage is common. Oyster shell scale (Lepidosaphus ulni) weakens or kills branches. Sawfly (Hoplocampa sp.) can infest the fruit. Tortricid moth larva (Argynotaenia quadrifusciana), gall midge and circulionids can damage flowers and fruit (719). Saskatoon is especially susceptible to the fungus Morilinia amelanchieris which causes mummy fruit; and mildew. Seedlings are susceptible to "damping off" (Pythium rhizoctonia) and leaf spot (Entomosporium maculatum). Gymnosporangia spp. (rusts) cause shoot dieback and fruit malformation (alternate hosts: Family Cupressaceae). Rust infection can be prevented by removing all common junipers growing near the saskatoons (186, 620, 208).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Saskatoon has thick, woody, widely branched roots with numerous fibrous roots. Seedlings grow slowly for first 2 or more years until root system is established. Provides good medium term soil stability once properly established (621). Is rated "good" for soil stability (338). It spreads by stolons to form dense thickets (312).

Adaptation to Disturbance

Saskatoon has been rated as having good adaptation to disturbance (338). In Alberta, it was found to be rare on disturbance sites in the northern and central east slopes of the Rocky Mountains. It was more common on disturbances in the south (365). Saskatoon requires removal of humus to become established by seed and this occurs with fires and mechanical disturbance (620). Increased plant density from sucker regeneration resulted under regime of annual spring burning in east central Alberta (604). Present in both early and later successional stages after fire. Can resprout but requires some time to regrow to pre-fire form (661).

Competitive Ability

Tolerant of competition from other species on sites disturbed by fire (661).

Commercial Value

Ornamental; sweet fruit used locally for preserves, pies, leathers and wines; wildlife forage and cover (443, 419, 186). A saskatoon fruit crop industry has been started with orchards, packing plant and commercial winery (619).

Palatability and Nutritive Value

In general shrubs receive highest utilization by deer; seedlings are much less utilized (472). Moderate use by mule deer (245). Heavy use reported by elk, moose (392) and range cattle (681, 699). Saskatoon buds provide winter food for sharp-tailed grouse (683). Provides shelter for mule deer (439). Rated as having moderate to good palatability (427, 337). Moderate palatability to mule deer (726). Highly palatable to snowshoe hare

(698). Vegetative parts of saskatoon (except fruit) contain pruasin, a glucoside that releases hydrogen cyanide upon hydrolysis. Toxicity of saskatoon browse to cattle and mule deer is attributed to HCN rapidly released by rumen microbial enzymes (680). Large intakes can be fatal to domestic or wild animals. Most hazardous period is spring when browse contains high levels of prunasin in both leaves and twigs (613, 681). Amelanchier alnifolia var. cusickii was found to have much higher concentrations than A. alnifolia var. alnifolia (613). With advancing maturity over the growing season, there is an increase in fibre and lignin and decrease in crude protein. Calcium, phosphorus, magnesium and potassium changes over the growing season (735). Calcium and protein contents of serviceberry sufficient to meet maintenance requirement of sheep and cattle during the growing season (629). Fruit is eaten by many birds and mammals (621).

Seed or Planting Stock Availability

Some native seed is being collected, propagated and sold (349) but stocks are generally scarce. Seed available from Northplan Seed Producers, available at local nurseries. Approximately 45 000 seeds/lb (639).

Over 12 named cultivars have been released for fruit production; plus one ornamental (J. Davidson pers. comm.). Cultivars developed include: "Regent", "Northline", "Parkhill", "Porters", "Pembina", "Smoky", "Thiessen", "Forestburg" and "Honeywood" (684, 686). Can be grafted onto Craetaegus arnoldina Sang. and Sorbus aucuparia L. stocks (693).

Methods and Ease of Establishment

Germination largely genetically controlled but some influence from environmental factors. Viability of seed lots from the wild varies greatly 3-67% (600). Seeds have embryo dormancy (617) and seed coat impermeability. Fruit should be collected when ripe (July or August). Seed crops can be periodic i.e. every 3 to 5 years. Screen, macerate with water, float off and dry. Alternatively clean with Dybvig seed cleaner and then dry prior to storage (Howe pers. comm). Store seed as cold as possible, in sealed onctianers to prevent dessiccation (186). Cold stratify at 5°C for 120 days. Alternatively, stratify for 60 days at 20°C and 120 days at 5°C or dip in concentrated sulfuric acid for 15 minutes followed by 120 days cold stratification (Howe pers. comm). Good germination reported with 24 hour soak in water followed by cold stratification (2-3°C) for 90 days (667) or 12 weeks (621). Sow seeds 1 to 2 cm deep. Sow fresh seed in August. Alternatively sow in spring with stratified seed. Light shade or mulch is beneficial (Howe pers. comm). Seedlings need half shade for one year (419). Seedlings
require bare mineral soil to become established, and will not survive in humus or in full shade (620).

Variable results obtained with vegetative propagation (607, 631, 634, 649, 656). Root sprouts, root cuttings and divisions of the root crown considered reliable (186). Root cuttings collected from parent plants, cut into 5 cm pieces, stored at 4°C for 2 months and then placed in plastic bags filled with peat moss and stored in the dark at 21°C. When shoots are evident (2 to 4 weeks) roots are covered with soil. Resultant softwood etiolated cuttings are removed after 1 to 2 weeks and rooted in a moist bed (Howe pers. comm). Good rooting success (99%) reported when softwood cuttings taken from etiolated stock material (694). Shoots can be grown in liquid media from excised plant tips (650). Good success with tissue culture production but varied with cultivar and source of explant (actively growing 1/2 year old plants best) (701, 702).

Fall planting is recommended provided the plants are allowed to go dormant and harden off naturally (621). Best establishment from bare root stock planted in spring compared to direct seeding in fall or transplanting potted seedlings in spring (628).

Current Status for Reclamation

Saskatoon was used for erosion control on easily eroded coarse textured soil in northeastern B.C. (431). Survival rates at oil sands reclamation sites have been good (645, 641, 706). However, growth rate on amended tailings sand was relatively poor (641, 706). It responds negatively to heavy groundcover (667). Saskatoon planted on waste rock in south central B.C. had good survival after 1 year. Poor survival when planted in tailings (667). Saskatoon wildlings transplanted to sand dunes in northern Alberta had excellent survival rates (258). Good survival of bare root stock in eastern Washington (419).

Saskatoon has good drought tolerance once established and is found on a wide range of soil textures. Establishment is enhanced by partial shade and reduced dessiccation, but thereafter good health requires full sun. It generally has a good growth rate and has potential for erosion control. It is a wide ranging species and there is the possibility that ecotypes exist. Further research is needed into the ecology and the genetic variability of this species and into improving methods of establishment.

Arctostaphylos rubra

SPECIES SUITABILITY MAP AND SUMMARY TABLE

☐ Recommended Area

Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance					
pH Tolerance Acid		X			
pH Tolerance Base			X		
Winter Hardiness	X				
Erosion Control				X	
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Moist to wet.				
Soil Preference	Sandy loam to silty clay loam, well to poorly drained.				

Arctostaphylos rubra (Rehder & Wils.) Fern.

SPECIES BIOLOGY

Taxonomy - Alpine Bearberry

Also Arctous rubra (Rehd. and Wilson) Nakai

Origin and Range

Native. Alaska to Baffin Island, south to St. Lawrence Bay, James Bay, and southern British Columbia. Also native to eastern Asia (443).

Growth Habit

It forms a prostrate evergreen shrub up to 0.3 m in height (690).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Red fruit bearberry propagates itself both by seeds and stolons (5).

Ecological Setting

In Alberta, it is commonly found in the Rocky Mountains, in moist subalpine forests. In northern Alberta, it occurs in lightly forested tamarack and open black spruce (generally well-drained) bog sites. In northern Canada, it is a common species of the tundra. It is often a pioneer on gravel floodplains (501, 690, 443). Common native associates: Salix bebbiana, Betula gladulosa, and Ledum groenlandicum.

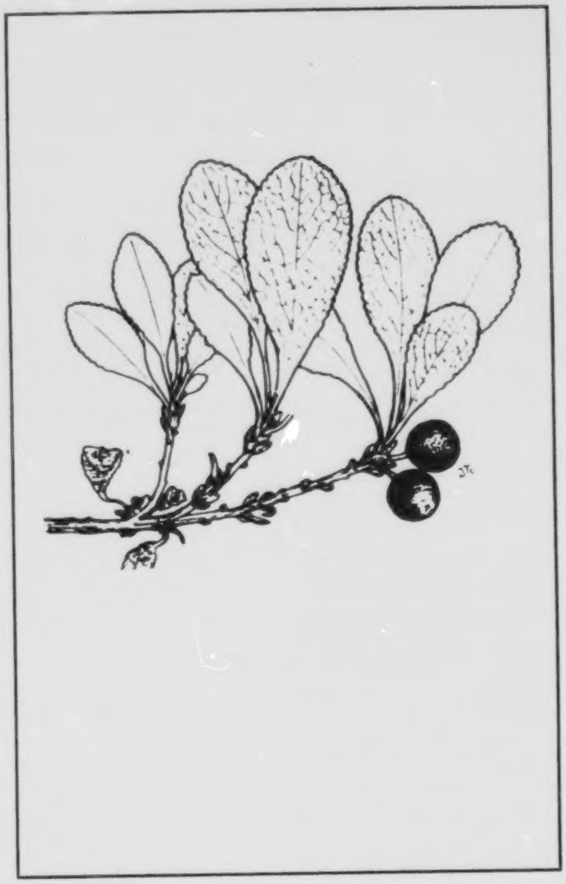
TOLERANCES

Soil Preferences

Adapted to a range of soil moisture conditions, from well drained through to poorly drained soils. Soil texture preferences range from sandy loam through to silty clay loam (5).

Nutrient Requirements

Low nutrient requirements assumed due to its growth on gravelly or boggy, low nutrient sites.



Soil Reaction

Alpine bearberry has a high acid tolerance (5). However, it is reported to always occur on soils derived from basic rocks in the Rocky Mountains (501).

Soil Salinity

No specific tolerances noted.

Drought

Observed to be less drought tolerant than common bearberry.

Heavy Metals and Hydrocarbons

At a crude oil spill site near Norman Wells, N.W.T., Arctostaphylos rubra was reported to have recovered within 2 to 3 years of the spill. On winter spill sites, Arctostaphylos rubra was markedly stimulated and it is suggested that this is probably due to reduced competition by other species killed by the spill (216).

Shade

Alpine bearberry has low shade tolerance (5).

Browsing

Tolerance to grazing is not known, but probably depends largely on the degree of physical disruption of plants by browsers/grazers.

Susceptibility to Disease and Insect Damage

No particular susceptibilities noted in the literature reviewed.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Alpine bearberry has a slow cover rate (5). It spreads by stolons to form trailing mats (5).

Adaptation to Disturbance

Alpine bearberry reinvades burned areas (458). It was reported to regenerate on a seismic line initially 98% bare and formed a carpet of plant material in the Mackenzie Delta region (194).

Competitive Ability

Observed to be relatively aggressive on favourable sites.

Commercial Value

No commercial value known. Fruits eaten by wildlife.

Palatability and Nutritive Value

Although the fruit is apparently watery and insipid, it is eaten by bears and many kinds of birds (501).

Seed or Planting Stock Availability

No source of commercial stock known.

Methods and Ease of Establishment

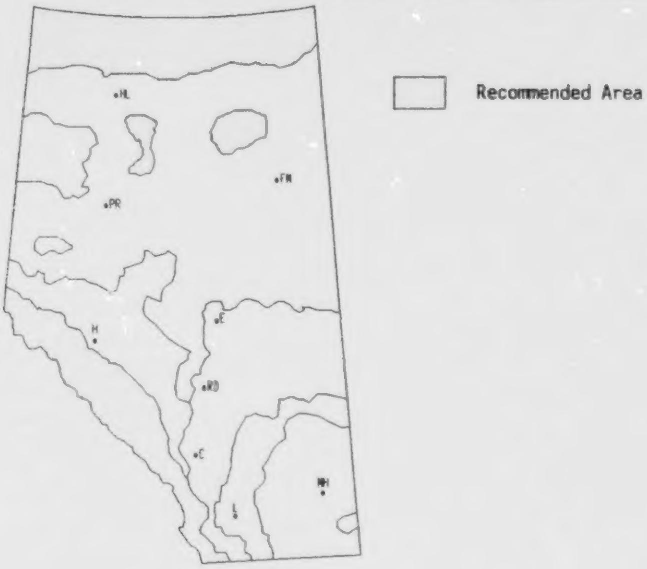
The seeds of Arctostaphylos have hard seedcoats and display embryo dormancy. The seedcoat can be scarified by soaking in sulphuric acid for 3 to 6 hours, stratifying at 25°C for 60 to 120 days, followed by moist chilling at 2 to 5°C for 60 to 90 days. Avoid excessive acid immersion. This can be monitored by breaking the endocarp and examining the embryo for acid damage (21, 419). Good germination of Arctostaphylos has been obtained by soaking the seeds in sulphuric acid for 2 to 5 hours, then sowing in early summer. Seeds germinate the following spring (419). Evergreen cuttings have been suggested as the best method of establishment. These can be collected in the fall (119).

Current Status for Reclamation

Alpine bearberry has been recommended for revegetation on well drained to wet sites in Alaska (5). It is found in moist situations in northern Alberta and in the Rocky Mountains to the subalpine. Alpine bearberry has shown some promise for revegetation of disturbed areas and is a pioneer on nutrient poor gravel floodplains. Propagation of this species by seed is a lengthy and difficult process and further research is needed into better methods of propagation.

Arctostaphylos uva-ursi

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance				X	X
pH Tolerance Acid			X		
pH Tolerance Base					
Winter Hardiness		X			
Erosion Control				X	
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Coarse textured, tolerates wide range, well drained.				

Arctostaphylos uva-ursi (L.) Spreng.

SPECIES BIOLOGY

Taxonomy - Kinnikinnick; Common Bearberry.

Also ssp. *adenotricha* (Fern and Maclr.) Calder and Taylor, ssp. *stipitata* Packer and Denford and, ssp. *longipilosa* Packer and Denford ssp. *arctostaphylos*.

Origin and Range

Native. Alaska to Newfoundland, south through the mountains to Georgia and California. Also native to northern Europe and Asia (419).

Growth Habit

A prostrate trailing shrub. Often forms trailing mats several metres across; evergreen (78, 443).

Nitrogen Fixing

Some disagreement exists in the literature as to nitrogen fixing ability of *Arctostaphylos uva-ursi*. Often reported to possess nitrogen fixing nodules. However, a recent paper indicates that these structures contained no endophytes and do not fix nitrogen. The structures were most likely latent buds (384).

Longevity - Long-lived perennial.

Self Propagation

Propagates itself both by seeds, by stolons and by rooting along the branches.

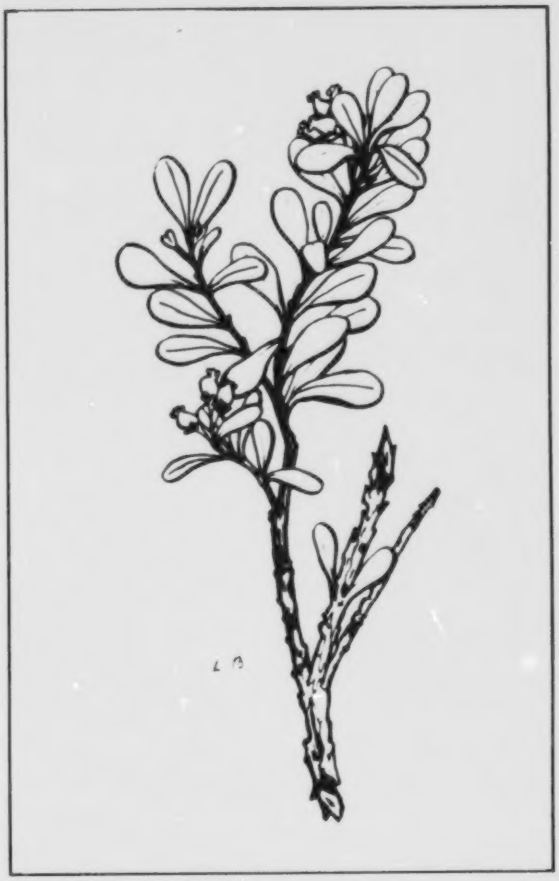
Ecological Setting

Common on dry sites in the boreal forest and throughout the prairies. Often found on eroded slopes or rock bluffs. Commonly found in open stands of jack pine or lodgepole pine on dry upland sites. Common native associates: *Pinus banksiana*, *Vaccinium myrtilloides*, *Oryzopsis pungens*, *Vaccinium vitis-idaea*, *Juniperus communis*, *Pinus contorta* var. *latifolia* (690, 78, 443).

TOLERANCES

Soil Preferences

Bearberry is found on a wide range of soil textures. It is commonly found on coarse textured soils that are well to excessively drained (5). Prefers gravelly or sandy loams (608).



Nutrient Requirements

Bearberry is commonly found on nutrient poor, coarse-textured soils and on gravel terraces (501) suggesting low nutrient requirements.

Soil Reaction

Bearberry characterized as having "moderate" acid tolerance relative to other woody plants (5).

Soil Salinity

No tolerance noted, but thought to be relatively intolerant based on known site preferences.

Drought

Can withstand excessively dry conditions (325). In a study in North Dakota most normal growth (66%) occurred during June when moisture and temperature conditions were optimum (416).

Heavy Metals and Hydrocarbons

Reported to be killed by diesel spills near Whitehorse (322).

Shade

Alternately described as having low shade tolerance (325), or preferring partial shade (608).

Browsing

Not known, but bearberry sustains use by elk and deer on winter ranges in Alberta and British Columbia.

Susceptibility to Disease and Insect Damage

Bearberry is host to yellow witches broom (parasite) which affects white, black and Engelmann spruce in Alberta. This disease is considered economically unimportant (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Bearberry has a moderate cover rate (325). It is often found on erosion susceptible, coarse textured soils and erosion slopes. It often forms trailing mats several metres in diameter (443). Low leaf fall is a factor reducing soil building capability. Observed to be only a fair erosion controller.

Adaptation to Disturbance

Bearberry possesses latent buds on horizontal stems which give plants the ability to resprout following disturbance or damage. Found to produce shoots under stressed conditions in the field (416). Bearberry is common in dry, open disturbed sites especially on coarse textured soils and road cutbanks throughout the eastern slopes of the Rocky Mountains in Alberta. It often invades disturbed sites by spreading from adjacent vegetation (365).

Competitive Ability

Aggressive on open sites but dies back in shady locations.

Commercial Value

Occasionally used as an ornamental, in which case, wildling stock is transplanted.

Palatability and Nutritive Value

Moderate use reported for mule deer throughout winter, spring and autumn (245).

Berries eaten by bears in the autumn, by many birds including ptarmigan, and small mammals (443). Berries provide winter food for grouse and wild turkey (608). Berries are important food for bears in early spring.

Seed or Planting Stock Availability

Seed is available commercially (349) but on a limited basis, and at high cost. Planting stock is available (e.g. 608).

Methods and Ease of Establishment

Seed should be collected in the fall. Seedcrops form every one to five years. Seed displays seedcoat and embryo dormancy. Soak seeds 2 to 5 hours in concentrated sulphuric acid; either sow outdoors in early summer for germination the following spring, or warm stratify at 25°C for 60 to 120 days, followed by moist chilling for 60 to 90 days at 2 to 5°C (21, 419). Another technique is to snip off pointed ends of seeds and stratify as above (germination times in this case will be longer). Time of germination reported as 15 to 30 days (indoors) and 20 to 40 days (outdoors) (119, 293). Germination capacity found to be in the order of 30 to 50%. Seedling susceptible to "damping off" (293). Evergreen cuttings taken in autumn regarded as the best establishment methods; seed treatment is time consuming (119). Problems still encountered with vegetative propagation: little success noted at Syncrude Canada Ltd. oil sands sites in Alberta (P. King, pers.comm.). The percentage of rooted cuttings and root volumes of cuttings were significantly increased when inoculum of ectomycorrhizal fungi was added to the rooting medium. There was also a specific interaction between a given bearberry cultivar and a particular fungus (260).

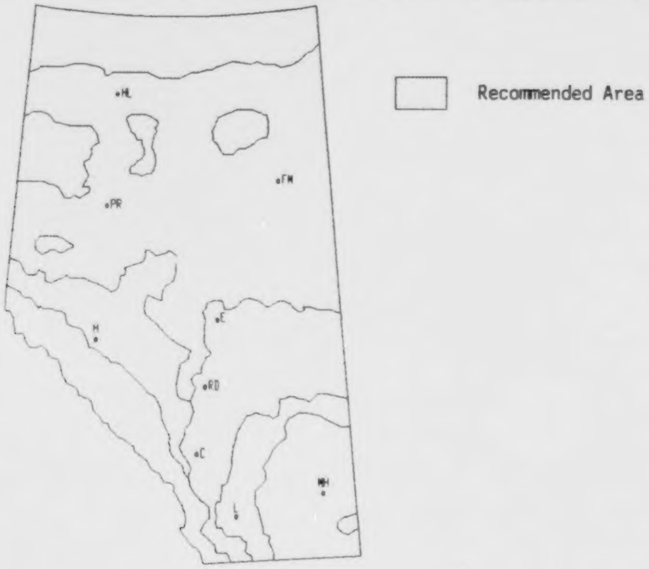
Current Status for Reclamation

Bearberry has been used for erosion control in northeastern B.C. on badly eroded, coarse textured soils (28). It has been recommended for revegetation under dry and well drained soil moisture conditions in Alaska. The suggested method of propagation was by seed or stem cuttings planted at a maximum spacing of 1 m by 1 m (5), although problems are still encountered with vegetative propagation at oil sands sites in Alberta (P. King, pers.comm.).

Bearberry is commonly found on dry coarse textured soils in open coniferous forest and is often a pioneer on disturbed sites. It spreads by stolons to form trailing mats which may be useful for erosion control. Methods of propagation of this species are still difficult and time consuming, and further research is needed in this area.

Betula papyrifera

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No __

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance			X			
Salt Tolerance					X	
pH Tolerance	Acid		3.2			
	Base					
Winter Hardiness			X			
Erosion Control				X		
Persistence			X			
Palatability				X		
Browse Tolerance				X		
Moisture Preference		Moist to wet, tolerates flooding.				
Soil Preference		Silty loam to sandy, well to imperfectly drained.				

Betula papyrifera Marsh.

SPECIES BIOLOGY

Taxonomy - Paperbirch; White Birch

A variable species including var. papyrifera, var. commutata (Regal) Fern. and var. subcordata (Rydb.) Sarg.

Origin and Range

Native. Paper birch is widely distributed in northern North America, from Alaska east to Labrador and Newfoundland, south to the northeastern states, Pennsylvania and Iowa and in the western states to Montana and northeastern Oregon (443, 419).

Growth Habit

Small to medium-sized tree usually 6 to 20 m high and 10 to 30 cm in diameter. It may grow up to 24 m in height and 60 cm in diameter (389, 391). It is deciduous (443).

Nitrogen Fixing - None

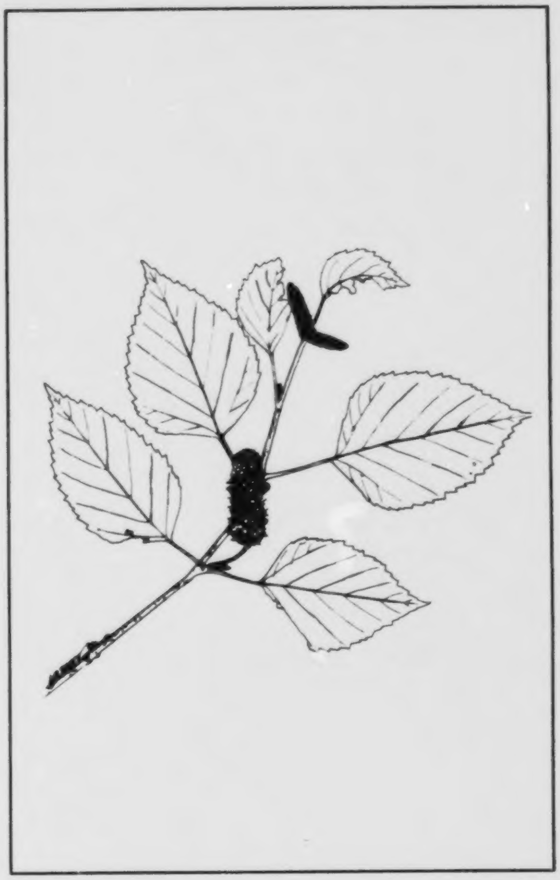
Longevity - Long-lived perennial.

Self Propagation

Paper birch usually establishes itself from seed. After being killed by fire, paper birch will often resprout from the base of the trunk (5, 205); also propagates from suckers (466).

Ecological Setting

Paper birch is widespread in central and northern Alberta on burned or cut-over areas where it often forms pure stands. As the forest matures it becomes restricted to openings. It is frequently found on thin rocky soils, or otherwise poor sites, to the subalpine. It also occurs in dry bogs (443, 205). It may be found along streams and riverbanks over the northern and eastern fringes of the prairies (205). Common native associates (upland mixed wood): Picea glauca, Populus tremuloides, Pinus banksiana and Amelanchier alnifolia.



TOLERANCES

Soil Preferences

Paper birch is adapted to a wide range of soils from well drained soils through to poorly drained ones that are usually waterlogged. It is also found on a wide range of soil textures (5). It does best on well drained sandy or silty loam soils (205).

Nutrient Requirements

Birches have been reported to have low requirements for P and Ca, but require moderate amounts of S and N (372).

Soil Reaction

Paper birch has moderate acid tolerance (5), and it has also been observed growing on semi-barren soils which are very acid (pH 3.2 to 4.4) (28).

Soil Salinity

No specific tolerances noted in the literature consulted.

Drought

Birches in general have deep, penetrating roots and high root:shoot ratios. This suggests that birch has a relatively high tolerance to drought. Furthermore, birches are often colonizers on coal spoil piles which are subject to high temperatures and droughty conditions (372, 28).

Heavy Metals and Hydrocarbons

Paper birch has been observed growing on acid soils with elevated levels of Ni, Cu and Al near Sudbury, Ontario (28). It is sensitive to oil spills. No sign of seedling establishment was observed three years after an oil spill killed stands of paper birch (216).

Shade

Appears to be relatively shade intolerant.

Browsing

Observed to resprout from root crowns when closely browsed, therefore at least somewhat tolerant to browsing.

Susceptibility to Disease and Insect Damage

Paper birch is susceptible to leaf spot, powdery mildew, "tinder cork", white spongy rot, pitted sap rot and brown cubicle rot, among others (198). Also observed to be susceptible to "birch dieback" and birch leaf miner (P. King, pers. comm.). Extensive rodent damage has been observed for paper birch planted on oil sands tailings in northern Alberta (345).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Paper birch has a moderate to fast growth rate and a slow cover rate (5, 428). It spreads by suckering from the parent plant (466). The roots of young birch seedlings generally penetrate deep in the soil (372) and can be expected to provide good stabilization.

Adaptation to Disturbance

Paper birch has very thin flammable bark and is easily killed by fire (205). Trees outside the burn area can supply seed for reestablishment because seed is disseminated by wind over great distances (460). Trees killed by fire may resprout from the base of the trunk (205). Paper birch has been reported to be a pioneer on rocky eroded hillsides with a few shallow soil pockets near Sudbury, Ontario (28), particularly after these soils received amendments of lime and phosphate to raise pH and fertility (479).

Competitive Ability

Paper birch is an aggressive pioneer.

Commercial Value

Paper birch has moderately heavy, hard, strong and even-grained wood. It is used primarily for pulpwood, veneers, plywood and furniture (443, 205). Paper birch is planted as an ornamental (448, 443) and is used for reclamation of mine spoils in the United States (33).

Palatability and Nutritive Value

Apparently moderately palatable as it is browsed at least occasionally. Often regarded as an important winter browse species for moose.

Seed or Planting Stock Availability

Native seeds are available (349) but supplies are short and seed is costly. Seedlings are also available.

Methods and Ease of Establishment

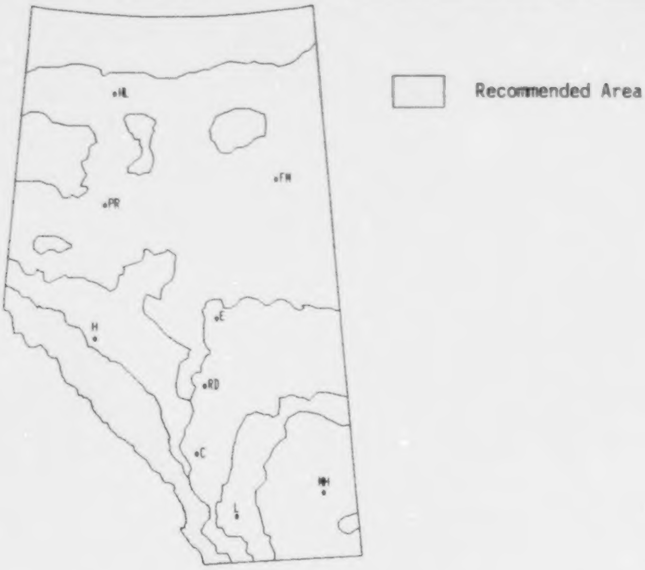
Birch seed is collected while the strobiles are still green and firm. They should be laid out to dry and the seed removed from the opened strobiles by shaking or flailing. Seeds can be separated from debris by screening (1/8 inch). Seed viability varies from year to year. Seed viability is usually 15 to 20% (119, 419). Viable seeds can be estimated by viewing seeds under transmitted light. They can be stored at room temperature for up to 2 years with a moisture content of 1 to 5%. Storage at -25 to 3°C (1 to 3% moisture content) may succeed for up to 10 years (P. King, pers.comm.). Seed stratification may not be necessary if seeds are germinated under light. Otherwise these may be stratified at 5°C for 60 to 70 days. Fall sow or spring sow stratified seed. Broadcast seed, and cover lightly. Seedlings require shade for 2 to 3 months in the first summer. Container seedlings are more easily produced than bare root stock (5). Also, layering, cuttings, budding and grafting are practical methods of establishment (21). Birches in general require high temperatures and plenty of light for germination and early development (372).

Current Status for Reclamation

In the subalpine zone of southeastern B.C., the low organic matter content and pH (range 6.5 to 8.5) of coal mine spoils causes poor survival of planted native tree species. Paper birch is an exception, however, and produces satisfactory results (292). Cuttings of paper birch planted on an unstable, water-saturated, gravelly side-slope and on an abandoned winter road near Norman Wells, N.W.T. failed to survive. Paper birch is regarded as unsuitable for slope stabilization in this location (110). On tests in the eastern slopes region of Alberta (subalpine) paper birch suffered heavy dieback and survival declined steadily (707). On amended tailings sand at Fort McMurray survival was high but growth after six years was mediocre and dieback was high (706, Suncor 1983). Paper birch is used for reclamation purposes in the eastern United States (33) and elsewhere in Canada (466), as well.

Ceanothus velutinus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance					
pH Tolerance Acid			X		
pH Tolerance Base					
Winter Hardiness		X			
Erosion Control		X			
Persistence		X			
Palatability		X	X	X	
Browse Tolerance			X		
Moisture Preference	Dry.				
Soil Preference	Moderately acidic substrate to neutral.				

Ceanothus velutinus Dougl. ex Hook.

SPECIES BIOLOGY

Taxonomy - Snow Brush; Deer Brush.

Origin and Range

Native. Snow brush is found in the coast ranges from British Columbia south to California and east to southwest Alberta, Montana, South Dakota and Colorado (419).

Growth Habit

A medium evergreen shrub 1 to 30 m high, snow brush is usually found growing in dense patches (690). It forms a spreading, dense round-topped bush. The thickets may be up to 10 m wide and are often dense and impenetrable (480).

Nitrogen Fixing

Snow brush fixes atmospheric nitrogen, which assists in its success (and that of neighbouring plants) on infertile soils (120, 480, 159, 107). In nitrogen-free media, Ceanothus plants were found to fix 760 mg N per plant in a 48 week period. About 60 kg N per annum was fixed under field conditions (33).

Longevity

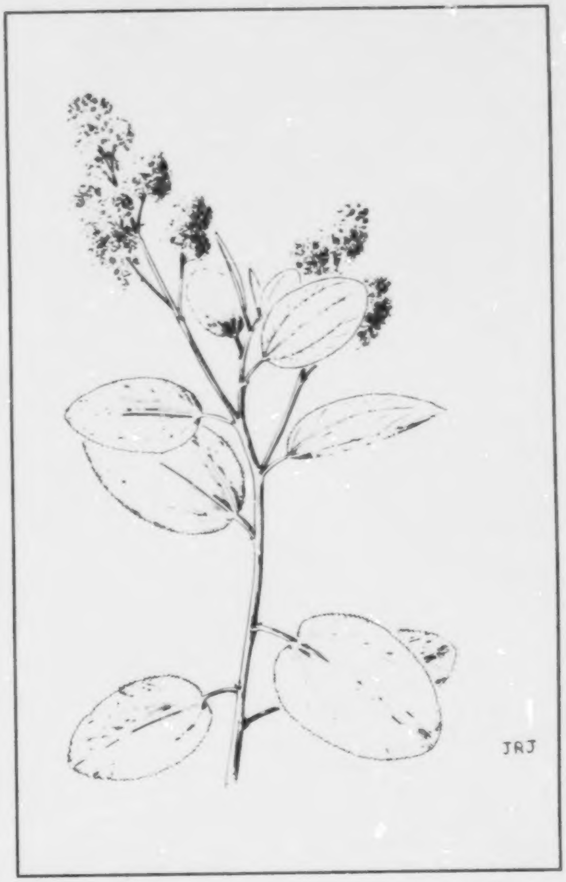
Long-lived perennial (243). Snow brush is apparently susceptible to winter die-back on exposed sites (415).

Self Propagation

Snow brush spreads by seed and will spread by root sprouts after logging or fire (480).

Ecological Setting

Ceanothus spp. are largely confined to the Pacific coast region of North America. In Alberta, Ceanothus velutinus is mainly found on mountain slopes in the southwestern corner of the province. It can be found from sea level to high mountains. It is an understory shrub characteristic of Ponderosa pine (Pinus ponderosa) and Douglas-fir (Pseudotsuga mensiesii) forests (690, 419, 480).



TOLERANCES

Soil Preferences

Snow brush is adapted to moderately acid to neutral soil. It is often the most vigorous shrub on granite (acidic) substrate (480). It is generally found on dry sites (120).

Nutrient Requirements

Found on sites with poor nutrient status, so low requirements suspected.

Soil Reaction

Does best on neutral to moderately acidic soils. No specific pH ranges noted.

Soil Salinity

No specific tolerance noted.

Drought

Tolerant of dry conditions, but resistance to actual drought not known. Species has the ability to fold leaves to reduce transpirational loss when leaves exposed to heat.

Heavy Metals and Hydrocarbons

No specific tolerances noted in literature reviewed.

Shade

Likely moderately shade tolerant, due to its frequent occurrence under open forest types.

Browsing

Will resprout from root crowns, and apparently survives at least some browsing.

Susceptibility to Disease and Insect Damage

Aphids are a problem with this species (P. Ziemkiewicz, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Snow brush is a thicket forming shrub that spreads by root suckers (480). It is therefore presumed to bind soil and reduce erosion potential. Snow brush is rated as excellent for soil stabilizing (338).

Adaptation to Disturbance

Snow brush is often observed as a pioneer after fire (419). In a burned area in Oregon, snow brush germinated over much of the area one year after the fire, particularly in the ponderosa pine-sedge and ponderosa pine-mixed fir sites (15). It has been reported growing on mine spoil in British Columbia (120). It is rated as having good adaptation to disturbance (338). In California, maintenance of Ceanothus spp. is dependent on fire.

Competitive Ability

Observed to be moderately aggressive on open sites.

Commercial Value

Snow brush is an important winter forage for big game. It is also important for nitrogen fixation, erosion control, conservation and as an ornamental (480, 107, 608).

Palatability

The genus has been rated as having low value for wildlife (397), but C. velutinus is browsed by elk, deer, and mountain goat and often comprises an important component of high-elevation ungulate winter ranges. Valuable browse for big game and birds (608). Ceanothus has also been recommended as an understory plant for providing shelter for elk (437). Low growing ecotypes are more palatable than others (480). Moderate to heavy use by mule deer has been reported (245). Contains the poison, Saponen (P. Ziemkiewicz, pers.comm.).

Seed or Planting Stock Availability

Some native seed is known to be available from American dealers, but ecotype suitability is not known. Seedlings may also be available (e.g. 608).

Methods and Ease of Establishment

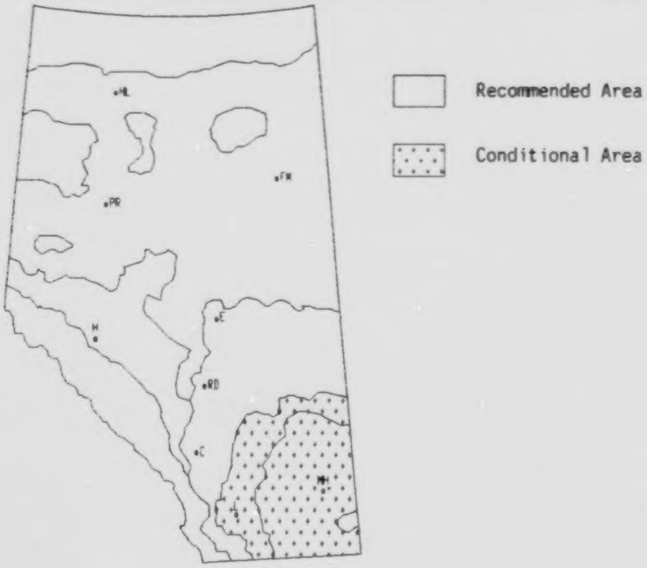
Seed should generally only be collected from healthy plants. Weak or diseased plants do not produce sound seed pods. These clusters should not be cut as the seed pods will not ripen properly. The pods split when ripe and eject seeds. The interval between seed crops is 1 to 3 years. Seed is apparently long-lived and can be stored at 2 to 5°C. It has seedcoat embryo dormancy. Soak in water at 90°C until the water is cool (or boil for 3 minutes), then cold stratify at 5°C for 60 to 90 days. Heat apparently renders the seed permeable to water. Seeds should be sown 0.3 to 0.6 cm deep in an acid planting medium (pH 6.5). Other methods of establishment include evergreen cuttings (in the fall) and root cuttings (119, 135, 120). Snow brush is also readily established from transplanted wildlings, containerized wildlings and bare root nursery stock (480). The species is ranked as having good establishment by transplanting, but only fair establishment by seeding (338). P. King (pers.comm.) reported best results with semi-hardwood root cuttings (72% rooting) treated with Hormodin (semi-hardwood formulation).

Current Status for Reclamation

Snow brush is a dense shrub with lateral growth habit. It has been variously described as slow growing and as an aggressive invader of disturbed sites. It fixes atmospheric nitrogen and is a valuable ungulate browse species. It is adapted to dry and acid soils and easily propagated from seed or root suckers. Snow brush has been used for erosion control on roadways and other disturbed sites (480). Survival of one year old bare root seedlings planted on road cut and fill sites in the Wenatchee National Forest (77 to 1 478 m ASL), eastern Washington, was variable after two years. Slopes ranged from 40% to greater than 70% and soil nutrient levels were very low. Snow brush had higher survival on road fill sites (25% to 74%) than on road cut sites (4% to 42%), probably due to less soil movement on the fill slopes. It is slow growing and susceptible to burial from moving soil. Snow brush has been suggested as a species suitable for revegetation in the Rocky Mountains of Alberta (331).

Cornus stolonifera

SPECIES SUITABILITY MAP AND SUMMARY TABLE


HL
FM
PR
E
H
RD
C
MH
Recommended Area
Conditional Area

Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance					X
pH Acid			X		
Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X	X	
Persistence		X			
Palatability		X	X		
Browse Tolerance		X			
Moisture Preference	Moist to wet, tolerates flooding.				
Soil Preference	Medium to coarse textured, tolerates wide range.				

Cornus stolonifera Michx.

SPECIES BIOLOGY

Taxonomy

Red Osier; Dogwood; Kinnikinnick

Origin and Range

Native. Newfoundland to Alaska, south to California, New Mexico and Nebraska, in northern United States from Wisconsin to New York (419).

Growth Habit

Deciduous, thicket forming shrub. Red osier averages 1 m to 2 m high. It can grow up to 5 m high and is many-stemmed. The lower branches may root at the tip (443, 312).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Methods include root sprouts, stolons, layering (5, 377). Plants flower when about 4 years old. Seeds are spread by birds (377).

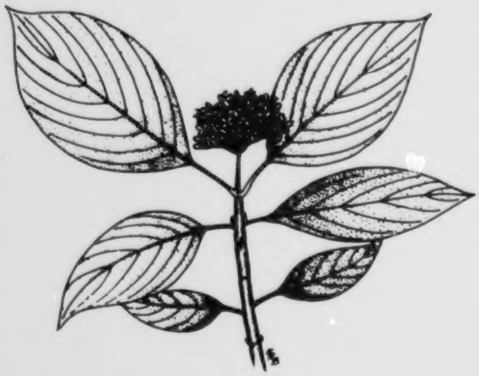
Ecological Setting

Red osier is found throughout the boreal forest region and is common in woodlands and coulees throughout the prairies. It is common in moist soil in clearings or open woodland, and on river banks and river flood plains. It is found over a wide range of elevations (1 370 to 3 050 m in the central Rocky Mountains). The common native associates are (Mixed-wood Forest): *Linnaea borealis*, *Vaccinium vitis-idaea*, *Ribes triste*, *Rosa acicularis*, *Alnus crispa*, *Viburnum edule* (690, 377, 399).

TOLERANCES

Soil Preferences

Red osier is found on a range of soil moisture conditions from well drained to poorly drained soils. It can withstand flooding during the growing season (5). It is also found in drier situations along forest margins and it often invades grasslands (377). Red osier does best on free draining soils with adequate available moisture. It is also found on a range of soil textures (5).



Nutrient Requirements

Appears to favour nutrient rich sites.

Soil Reaction

Red osier has medium acid tolerance (5). It is found on soils with various pH values, from moderately acidic to moderately alkaline (338, 377).

Soil Salinity

No specific tolerances noted.

Drought - Low drought tolerance (5).

Heavy Metals and Hydrocarbons

Red osier has a high tolerance to oil (282).

Shade

Red osier is slightly shade tolerant - prefers open sites, but will grow under light shade (356). May survive in relatively dense forests as a remnant.

Browsing

Often extensively browsed with little loss of vigour.

Susceptibility to Disease and Insect Damage

Some galls and leaf spots have been observed. No specific susceptibilities noted. Oyster shell scale can kill plants (P. Sims, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Red osier has a medium cover rate and will spread by root sprouts after it has been established (5). It therefore is able to provide some protection to soil surfaces.

Adaptation to Disturbance

It is known to invade disturbed alluvial sites.

Competitive Ability

Aggressive on preferred sites.

Commercial Value

Red osier is important in providing food and cover for wildlife and many birds, including ruffed grouse (377); it is also sometimes favoured as an ornamental (443).

Palatability and Nutritive Value

Moderate to heavy use of red osier by mule deer has been reported (245). It is a preferred browse species of moose during fall and winter, especially young twigs (443). Also browsed by elk (377). Red osier is useful in providing a heavy shrub layer suitable for shelter for mule deer (71).

Seed or Planting Stock Availability

Native seed is available from U.S. dealers. Ecotypic suitability is not known. A large range in seed weight has been reported: about 300 400 seeds/kg is typical; 44 kg of seed per 1 200 kg fruit can be expected; approximately 380 600 seeds/kg (639).

Methods and Ease of Establishment

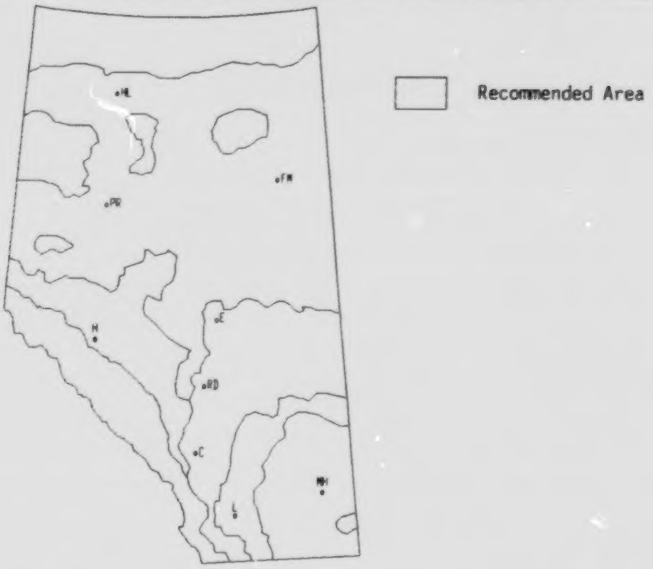
Seed can be collected in July or August (as soon as ripe). One to two years can be expected between good seed crops. Seed can be stored at -18°C for 1 or 2 years before planting out. Seed has an embryo dormancy and requires stratification at 2 to 5°C for 60 to 90 days (119, 434). Stratification at 5°C also produces good (98%) germination (102). Seed is best sown in the fall at depths of 0.6 to 1.25 cm (119, 208). Hardwood cuttings should be planted in autumn; softwood cuttings in summer (174). It is easily propagated from stem cuttings (443) and root cuttings (174).

Current Status for Reclamation

Well adapted to growth on amended tailings sand at Fort McMurray. Survival is high and dieback light (645, 706). Red osier was unable to compete with grass cover (149, 667). Red osier has been recommended for revegetation on well drained to wet sites in Alaska. The maximum spacing suggested was approximately 1.3 m by 1.3 m (5). Though it has been widely used for soil stabilization (42), some authors have recommended that it not be used for controlling slope erosion (110).

Dryas drummondii

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance			X			
Salt Tolerance						X
pH Tolerance	Acid				X	
	Base			8.5		
Winter Hardiness		X				
Erosion Control		X	X			
Persistence		X	X			
Palatability						X
Browse Tolerance						X
Moisture Preference		Dry to moist, tolerates flooding.				
Soil Preference		Coarse gravels of gravel bars and glacial outwash.				

Dryas drummondii Richards.

SPECIES BIOLOGY

Taxonomy - Yellow Dryad; Mountain Avens.

Origin and Range

Native to North America (214), with circumpolar distribution. Range extends from Alaska to Mexico generally along the Rocky Mountains and adjacent foothills. Associated with rocky slopes, gravel bars, and glacial outwash (160, 312, 405).

Growth Habit

Forms extensive continuous mats (160) with flower stalks up to 25 cm high (690). Stem from long, woody caudex (214), leaves all basal (214), with extensive root system (160).

Nitrogen Fixing

Mountain avens is associated with nitrogen fixing endophytic fungi on root nodules (similar to that observed in Alnus); nitrogen content of the upper 5 cm of soil increased by almost 200% during 28 years of Dryas cover in Alaska (160, 105), thus aiding survival and stimulating growth of woody plants. Root nodules are usually found 15 cm or more beneath the surface (251).

Longevity

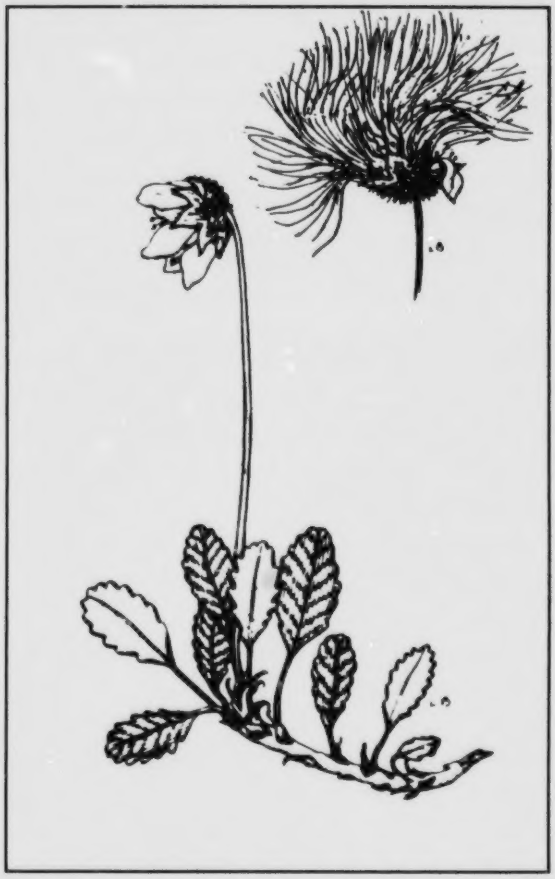
A perennial evergreen shrub (405). Initial colonization of barren ground by mountain avens may take 10 years; plants usually disappear within 20 to 30 years because of shading by other plants. Holds position as first dominant plant species on deglaciated terrain for 20 to 40 years, as noted in Alaska (251).

Self Propagation

Monoclinous (i.e. with bisexual flowers on all plants) (405). Wind-dispersed fruits enhance its colonizing ability (251). Good self-seeding.

Ecological Setting

Subalpine and boreal type forests, particularly dry sites on river gravel bars, to at least 1 100 m ASL (214). Preferred water table depth is noted at 60 cm and favoured moisture regime is considered on newly deglaciated terrain and noted to speed up rate of succession to a fully developed forest by as much as 20 to 30 years (251).



TOLERANCES

Soil Preferences

Associated with coarse gravelly soils of river bars. The species is adapted to the dry conditions of the tops of gravel bars where most fine sand and silt have been removed by flood waters (160). Sites are characterized by low availability of nutrients and low moisture-holding capacity of soil. On newly deglaciated terrain, mountain avens is conspicuous on raw sands, gravels, and silt loams of till and outwash, and occurs on surfaces more than 10 years and less than 60 years old (251).

Nutrient Requirements

with low nitrogen content (251). Capable of growing vigorously at low nitrogen levels characteristic of glacial debris (22).

Soil Reaction

Noted to be growing best on soils with pH in the range of 7.8 to 8.5, in Alaska. Dryas growth has been associated with slight increases in soil acidity after about 20 years (251).

Soil Salinity

Appears to be restricted to calcareous substrata and to grow best on soils with a calcium carbonate content of about 5% (of the fine earth fraction) in Alaska (251), and calcareous gravels bars in the mountains (185).

Drought

Mountain avens are well adapted to dry conditions. Adaptations include low spreading growth form, extensive root systems, leathery leaves, and accumulation of litter throughout annual leaf fall, which increases the moisture holding capacity of the soil (160).

Heavy Metals and Hydrocarbons

A related species, D. integrifolia, shows tolerance to crude oil contact and spills at high-arctic tundra sites (216). No other tolerances have been noted.

Shade

Dryas is extremely shade intolerant, and usually disappears within 20 to 30 years because of shading by other plants (140).

Browsing

Not applicable, since use by wildlife is virtually nonexistent.

Susceptibility to Disease and Insect Damage

No specific susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Annual leaf fall causes an accumulation of litter which increases the moisture holding capacity of the soil (160). The extensive root system contributes to erosion control capability. Noted for rapid stabilization of soil surfaces against erosion on newly glaciated terrain in Alaska (251).

Adaptation to Disturbance

Mountain avens is an efficient colonizer of coarse textured, gravelly soils of river bars subject to flooding and related disturbance. Dryas species also occupy alpine areas disturbed by frost heaving (160).

Competitive Ability

Very aggressive pioneer on preferred sites. Dryas usually disappears within 20 to 30 years after initial colonization because of shading by other plants. Dryas creates conditions suitable for a Populus community (251).

Commercial Value

Ornamental value associated with growth form and flowers (405).

Palatability and Nutritive Value

Generally not eaten by wildlife. Should be considered unpalatable.

Seed or Planting Stock Availability

Seed is easily collected from pure native stands.

Methods and Ease of Establishment

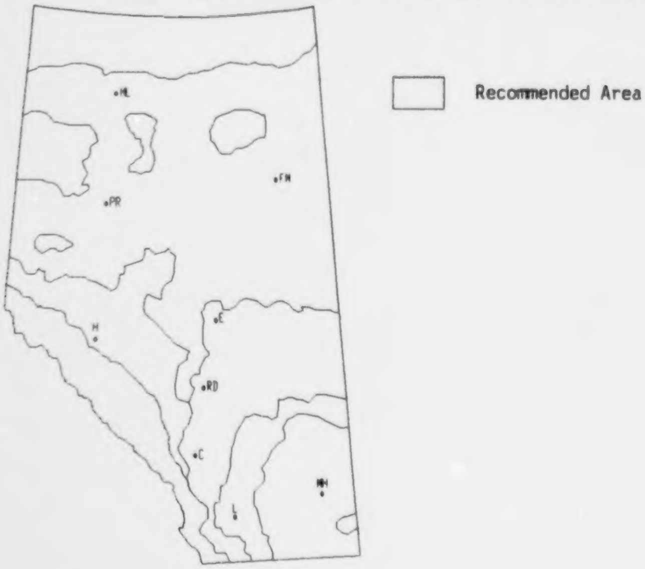
Mainly by seed which is easily collected and germinates well (J. Weijer, pers.comm.).

Current Status for Reclamation

Yellow mountain avens is a common native invader of river bars and glacial outwashes. The species has not apparently been incorporated into full scale revegetation operations. Noted as growing on bedrock spoil material at an abandoned coal strip mine, near Cadomin, an area subject to high winds, soil moisture deficiency, and abrasive effects of air borne weathered spoil particles (357). Encouraging attributes include extensive root system and spreading habit, primary successional status, adaptation to dry sites, adaptation to high elevations and its nitrogen fixing ability.

Dryas octopetala

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No_X_

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X			
Salt Tolerance				X	
pH Acid				X	
Tolerance Base			X	X	
Winter Hardiness	X				
Erosion Control		X			
Persistence			X		
Palatability					X
Browse Tolerance					
Moisture Preference	Dry to moist.				
Soil Preference	Rocky infertile moderately drained, tolerates frost boils and soil creep.				

Dryas octopetala L. ssp. hookeriana (Juz.) Hult.

SPECIES BIOLOGY

Taxonomy - White Dryad.

Origin and Range

Native to western North America, with circumpolar distribution. Range extends along the Rocky Mountains from Alaska to Mexico (214).

Growth Habit

Dwarf evergreen shrub forming small dense mats (690).

Nitrogen Fixing

Described as nodulated plants capable of fixing atmospheric nitrogen (25).

Longevity - Perennial (405).

Self Propagation

Observed to propagate by seed and matted habit.

Ecological Setting

Generally on rocky areas; high mountains, mostly above timberline (312); alpine heaths to at least 2 000 m ASL (214). Noted to develop on well drained bare surfaces such as deglaciated terrain, although less frequently than D. drummondii, in Alaska (25).

TOLERANCES

Soil Preferences

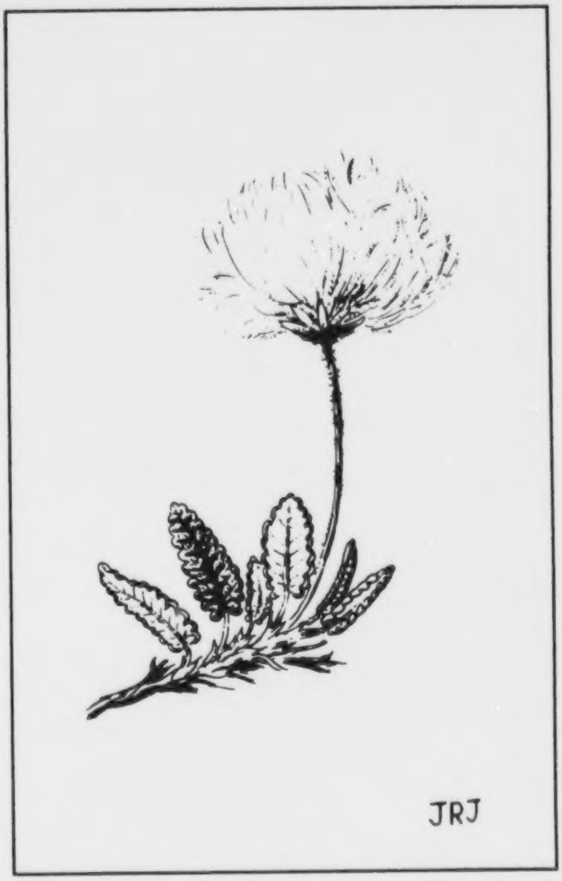
Observed on rocky infertile soils in exposed sites. Often associated with frost boils and soil creep areas. Does best on moderately well drained sites.

Nutrient Requirements

Thought to have low nutrient requirements due to its ability to colonize nutrient poor sites.

Soil Reaction

Appears to favour soils derived from basic materials; neutral to slightly basic pH is expected to be best.



Soil Salinity

Not thought to be particularly tolerant of saline conditions.

Drought

Found thriving on sites with high moisture stress. Adaptations to dry sites include leathery leaves, pubescence and low growth.

Heavy Metals and Hydrocarbons

A related species, D. integrifolia, shows tolerance and good ability to survive crude oil contact and spills at high-arctic tundra sites (216). No other tolerances noted.

Shade

Generally out competed on shady sites.

Browsing

Not generally eaten, therefore tolerance is not known.

Susceptibility to Disease and Insect Damage

No particular susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The ability of white dryad to fix nitrogen and colonize naturally unstable sites indicates a high capability for erosion control.

Adaptation to Disturbance

Invades suitable disturbed sites.

Competitive Ability

Highly competitive on suitable sites due to spreading habit.

Commercial Value

Some ornamental value (405), otherwise the species value is limited to its erosion control characteristics.

Palatability and Nutritive Value

Not generally eaten by wildlife although the seed may occasionally be eaten by birds.

Seed or Planting Stock Availability

Seed is easily collected, but not known to be available commercially.

Methods and Ease of Establishment

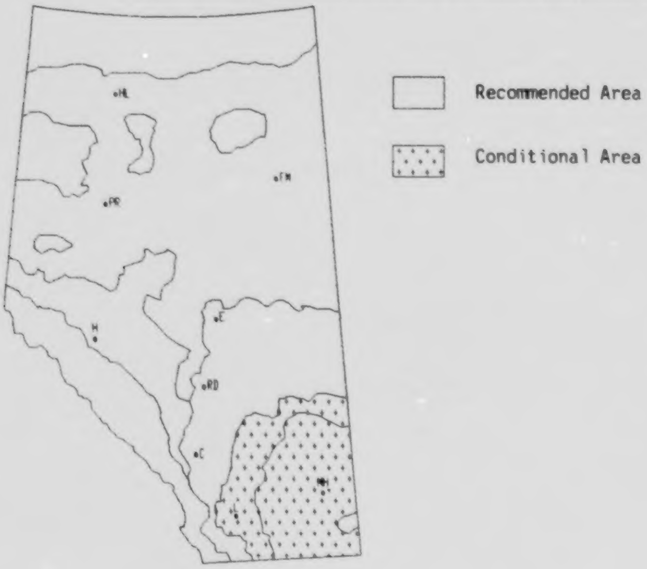
Reported to have very high (99 %) germination (J. Weijer, pers.comm.). Vegetative propagation is also thought to be worth investigating.

Current Status for Reclamation

White dryad is reported to show good potential for revegetation of calcareous coal mine spoils in alpine areas of Montana (209). Factors cited as favourable include natural association with calcareous rocky sites, nitrogen fixing ability, and pioneering ability.

Elaeagnus commutata

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance			X		
pH Acid			X		
Tolerance Base			X		
Winter Hardiness		X			
Erosion Control		X	X		
Persistence		X			
Palatability				X	
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Medium textured(silt loam to sandy loam), well drained.				

Elaeagnus commutata Bernh. ex. Rydb.

SPECIES BIOLOGY

Taxonomy - Silver-berry; Wolf Willow.

Origin and Range

Native. Alaska and the Yukon Territory east to Great Slave Lake, James Bay and the Gaspe Peninsula; south to Minnesota, South Dakota, Colorado and Utah.

Growth Habit

Deciduous thicket-forming shrub; from 1 to 4 m high (312).

Nitrogen Fixing

Silver-berry fixes nitrogen under most conditions (329). It is associated with the N_2-fixing actinomycete Frankia and vesicular-arbuscular mycorrhizae (728). Poplar growing adjacent to silver-berry stands show higher tree production, higher percentage N in leaves and litter, and a greater quantity of N in above-ground parts than in poplar growing some distance away (470).

Longevity - Long-lived perennial.

Self Propagation - Seeds, root sprouts (5).

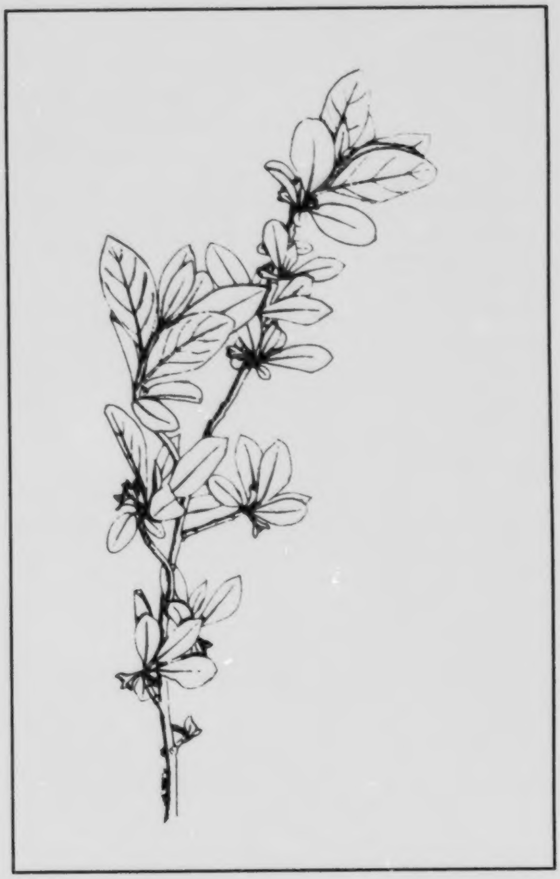
Ecological Setting

Common on valley slopes throughout the Canadian prairies where adequate moisture is available; often on the edge of aspen groves (312). On rocky south-facing slopes and river sandbars in the interior of Alaska; occurs over a wide range of elevations (119, 214). Common native associates (Alberta): Poa pratensis, Juncus balticus, Rosa acicularis, Populus tremuloides.

TOLERANCES

Soil Preferences

Silver-berry prefers well drained soils (5); it is largely confined to medium textured soils (silt loam to sandy loam) (690, 5, 332).



Nutrient Requirements

The species is often observed on poor sites such as erosion slopes in Alberta (306, 332). Twenty week old seedlings grown in the greenhouse were larger when fertilized; however, they had considerably fewer nodules (690). This may have some effect on the quality of the stock for outplanting.

Soil Reaction

The species displays moderate acid tolerance (5).

Soil Salinity

Silver-berry is often found on moderately saline sites.

Drought

Moderate; can tolerate soils with low water-holding capacity (5). However, low survival of this species on amended tailings sands was attributed to low drought tolerance (A. Fedkenheuer, pers.comm.).

Heavy Metals and Hydrocarbons

No specific tolerances have been noted.

Shade - Low shade tolerance (5).

Browsing

Moderate grazing tolerance (430).

Susceptibility to Disease and Insect Damage

Susceptible to leaf spot, leaf rust, dieback and root rot (Peniophora cremea) (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Although it has a slow cover rate (5) it is adapted to soils with high erosion susceptibility; it has been used for erosion control (120). Spreads rapidly on amended tailings sand (643).

Adaptation to Disturbance

Spreads rapidly in overgrazed pastures throughout the aspen parkland (312).

Competitive Ability

Thought to be able to maintain its cover, but not highly aggressive.

Commercial Value

Windbreaks, ornamental (443), and erosion control (120).

Palatability and Nutritive Value

Some use by mule deer (245) and bighorn sheep (144); reported to have low palatability (427). Increased nitrogen content of forage plants under silver-berry, particularly Kentucky bluegrass (Poa pratensis), makes forage more desirable for grazing livestock (470).

Seed or Planting Stock Availability

Very small quantities of seed are available commercially. Approximately 20 to 65 kg of seed can be expected from 100 kg of fruit, depending on the seed collection date.

Methods and Ease of Establishment

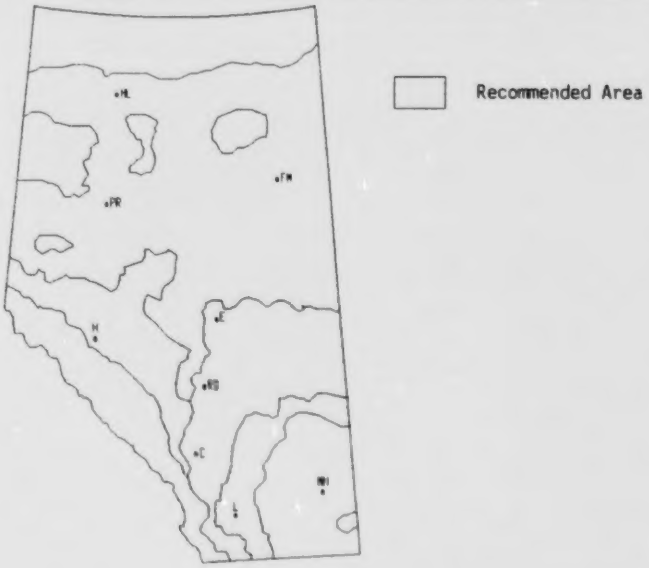
Seed crops are produced every 1 to 2 years. Seed should be collected between August and October. Approximately one man-day is required to collect 1 kg of seed (119). Seed has an embryo dormancy, therefore fall sowing or stratification at 5°C for 60 days is recommended. Sow seeds 1.0 to 2.0 cm below surface, at 180 to 270 seeds/m^2 in mulched beds (486). Hydroseeding has been successful (144); container seedlings (207) and bare root stock (434) can be produced successfully. Hardwood cuttings taken in fall and planted in spring (120, 119) and root cuttings (5) can also be successful.

Current Status for Reclamation

Well adapted to amended tailings sand at Fort McMurray. Survival remained high after seven years, growth and vigour were good and reproduction by rhizomes was vigorous (643, 706, 149). Inoculated silver-berry outplanted onto tailings sand had considerably lower survival than uninoculated plants; however, the inoculated survivors were considerably larger and had more nodules (728). In northeastern British Columbia, seedlings are reported to have a 60% first year survival rate when transplanted to a sandy soil on a steep, unstable slope (431).

Juniperus communis

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid		X			
pH Tolerance Base				X	
Winter Hardiness		X			
Erosion Control				X	
Persistence		X			
Palatability				X	X
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Silt loam to sand to coarse texture, well drained.				

Juniperus communis L.

SPECIES BIOLOGY

Taxonomy - Ground Juniper; Common Juniper.

Also J. communis var. saxatilis Pall and var. depressa Pursh. Syme, J. sibirica Burgsa.

Origin and Range

Native. Greenland, Newfoundland to Alaska south to Arizona, New Mexico, Georgia and South Carolina. Also in Europe and Asia. Most widespread tree species in the north temperature zone (443).

Growth Habit

A (usually) prostrate shrub. May grow up to 1.0 m. Evergreen (443) forms clumps up to 3 m in diameter (443). Reaches tree size in Europe (443).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Propagates itself by seed (5).

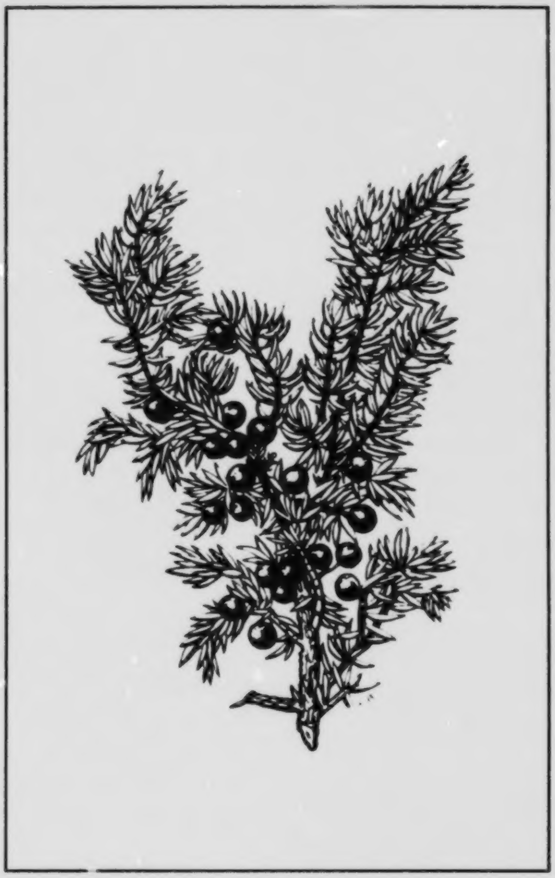
Ecological Setting

J. communis var. depressa common on light, rocky soil throughout most of the prairies (78). Common juniper is a common species of woods and open slopes throughout most of Alberta (690). It extends from the lower foothills and montane zones into the upper subalpine. It is commonly found on dry open slopes with southerly exposures. Common juniper is characteristically associated with buffaloberry and common bearberry in dry, open lodgepole pine forests (365).

TOLERANCES

Soil Preferences

Adapted to generally dry sites, from soils with no moisture limitations to excessively drained soils with severe limitations due to low water holding capacity. Found on a range of soil textures from silt loam through to sand. Most common on coarse textured soils (5).



Nutrient Requirements

Expected to have low nutrient requirements due to its ability to grow on poor sites.

Soil Reaction

Ground juniper has high acid tolerance (5).

Soil Salinity

No salinity tolerance information noted, although not generally found on saline soils.

Drought

Appears to be relatively tolerant of low soil moisture conditions; drought tolerant (608).

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Variously low shade tolerance (5) and shade tolerant (608).

Browsing

Will generally regrow from root crowns.

Susceptibility to Disease and Insect Damage

Juniper seedlings are resistant to "damping off" disease and root rot (419). They are susceptible to cedar blight caused by Phomopsis juniperovora and cedar apple rust (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Reported to have a slow cover rate (5). The species provides some erosion protection once shrubs are sizeable, but stabilizing ability generally is slight.

Adaptation to Disturbance

Reportedly does not regenerate vegetatively after being cut or killed by fire (5). Ground juniper is found on disturbed sites throughout the latitudinal range of the eastern slopes of Alberta where a seed source is nearby. However, it is not an aggressive pioneer (365).

Competitive Ability

Observed to be fairly aggressive on favourable sites.

Commercial Value

The fruits of some junipers are used for flavouring in the manufacture of gin. Used occasionally as an ornamental.

Palatability and Nutritive Value

Not generally eaten by wildlife, although fruits may be used to a extent, especially by birds.

Seed or Planting Stock Availability

Thought to be available in seedling or small shrub form from commercial distributors (e.g. 608). Approximately 35 kg of seed/100 kg fruit (119).

Methods and Ease of Establishment

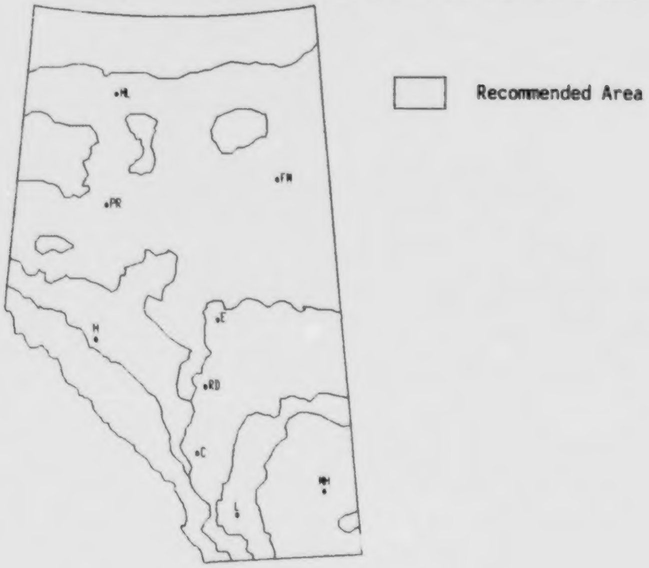
Irregular intervals can be expected between seed crops. Cones mature in 2 to 3 years, and are persistent on the plant. Collect seeds between August and October. Seeds may be stored either as dried fruits or as cleaned seeds (419). Seeds can be cleaned with Dybvig seed cleaner. Seeds can be stored for fairly long periods in sealed containers at -1°C to 4°C (419). Unstratified seed may be sown in the fall and mulched in the seedbed until germination during the second spring after planting. Juniper seedlings are reported to be susceptible to frost heaving (419). Warm stratify for 45 to 90 days followed by cold stratification (5°C) for 90+ days; seeds may be sown in fall for germination the following spring (119). Propagation from seed has been reported to be difficult (P. King, pers.comm.). Evergreen cuttings should be taken in autumn (119). Common juniper has been recommended for revegetation in southeastern Alaska. The suggested method is seed or seedlings planted at a maximum spacing of 2 m by 2 m on dry or well drained sites (5). It is generally planted as 2-1 stock (419).

Current Status for Reclamation

Ground juniper is found throughout Alberta on coarse textured soil susceptible to drought and is tolerant of acid soils. It is considered unpalatable. Although it is found on disturbed sites it is a slow pioneer. Germination from seed may also be difficult. It may be of some use for reclamation on dry, coarse textured soils where erosion control is not an important consideration.

Juniperus horizontalis

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance	X	X			
Salt Tolerance				X	
pH Tolerance Acid		X			
pH Tolerance Base		X			
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X	X		
Browse Tolerance		X			
Moisture Preference	Dry.				
Soil Preference	Silt loam to sand, rapidly to moderately well drained.				

Juniperus horizontalis Moench

SPECIES BIOLOGY

Taxonomy - Creeping Juniper

Also *Sabina horizontalis* (Moench) Rydb.

Origin and Range

Native. Alaska east across Canada to Great Slave Lake, Hudson Bay, Labrador, Newfoundland, south to New York, Michigan, Iowa, and Colorado. At Banff and in the Crows Nest Pass, semi-erect individuals have been described. These may be hybrids between *Juniperus scopulorum* and *J. horizontalis* (690).

Growth Habit

A normally prostrate shrub. May be up to 1 m high in some places. Often forms large mats with long horizontal stems, often rooting (443, 312, 78). Evergreen (443).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

By seed and layering.

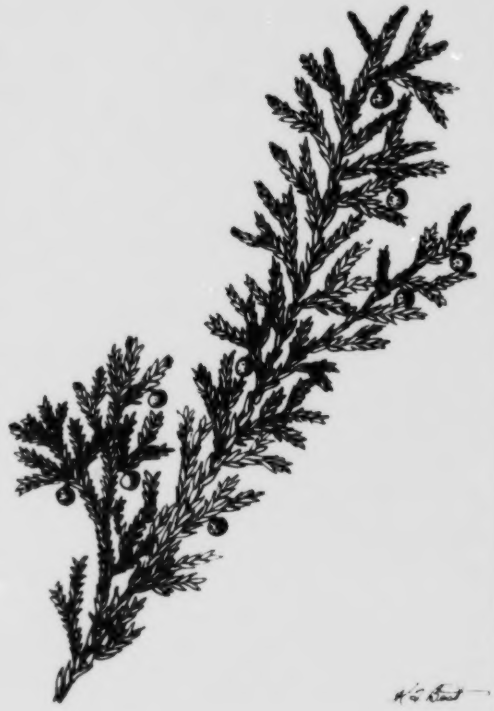
Ecological Setting

Very common throughout Alberta on dry banks; sandy and rocky hill sides (78, 312). Ascends to about 2 000 m ASL in Banff National Park (501).

TOLERANCES

Soil Preferences

Found on a wide range of soils, but most often on sands (426). Adapted to drier soils from moderately well drained soils to excessively drained soils. These soils may have severe limitations for plant growth due to very low water holding capacity or steep slopes (5). Soils may also be very thin (5). Creeping juniper is adapted to soils with textures ranging from silt loam to sand (5).



Nutrient Requirements

Expected to be low due to good growth on poor sites.

Soil Reaction

Apparently always found on calcareous soil (501), but also reported to have a high tolerance to acidic conditions (5).

Soil Salinity

No specific tolerances noted in the literature, but suspected to be slightly more tolerant of saline soils than other junipers.

Drought

Can withstand drought conditions that are intolerable to grasses (140); very drought tolerant (608).

Heavy Metals and Hydrocarbons

No indications of specific tolerances.

Shade

Creeping juniper has a low shade tolerance (5).

Browsing

Tends to maintain its cover on overgrazed ranges.

Susceptibility to Disease and Insect Damage

No specific susceptibilities noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Creeping juniper has a moderate cover rate (5), and may assist soil stabilization efforts.

Adaptation to Disturbance

Tends to slowly invade dry disturbed sites.

Competitive Ability

Not very aggressive. Tends to be out competed on all but the driest slopes.

Commercial Value

Soil stabilization (426), ornamental.

Palatability and Nutritive Value

Moderate to heavy use by mule deer has been reported (245).

Seed or Planting Stock Availability

Many horticultural cultivars are available as small shrubs (198, 426, 443).

Methods and Ease of Establishment

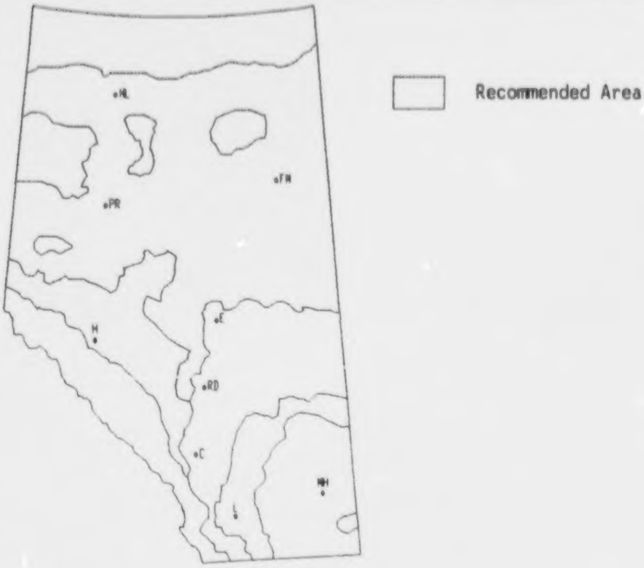
Creeping juniper can be established from seed, seedlings and transplants and possibly layering (332, 5). Seedlings and transplants should be spaced a maximum of 1.5 m by 1.5 m (5).

Current Status for Reclamation

Creeping juniper has been recommended for revegetation in southeastern Alaska (5). It is ideal for planting on steep banks or rocky slopes (140). This species is found on coarse textured soils throughout Alberta. It is highly tolerant of acid soils and apparently of alkaline soil. Creeping juniper has a high tolerance to drought and it has been used for soil stabilization (426). It may prove useful for reclamation and erosion control but further research is needed into methods of establishment.

Larix laricina

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Acid			5.5		
Tolerance Base				7.6	
Winter Hardiness		X			
Erosion Control			X	X	
Persistence		X			
Palatability					X
Browse Tolerance					X
Moisture Preference	Moist to wet.				
Soil Preference	Light soils to organic (peat), well to poorly drained.				

Larix laricina (Du Roi) K. Koch

SPECIES BIOLOGY

Taxonomy - Tamarack.

Origin and Range

Native. Alaska east across Canada along the northern treeline to Hudson Bay, Labrador and Newfoundland. Northeastern British Columbia southeast to New Jersey, Illinois and Minnesota. It also occurs locally to Maryland and West Virginia 9443, 419).

Growth Habit

Tamarack is a small to medium-sized deciduous tree 9 to 18 m high, with a straight trunk, 10 to 25 cm in diameter. In the far north it is often stunted, with a reduced crown (443, 205).

Nitrogen Fixing - None

Self Propagation - Tamarack spreads by seed (5).

Ecological Setting

Tamarack is generally found in cold, wet, poorly drained sites. It is generally restricted to Sphagnum bogs and swamps, or open muskegs. It is associated with black spruce (Picea mariana), alders (Alnus spp.) and willows (Salix spp.). In northern areas it may also be found on better drained sites where it has a growth rate comparable to black spruce. Common native associates: Populus tremuloides (on well drained sites), Betula papyrifera, and Abies balsamea (443, 205, 312); also occurs with Pinus banksiana (D. Walker, pers.comm.).

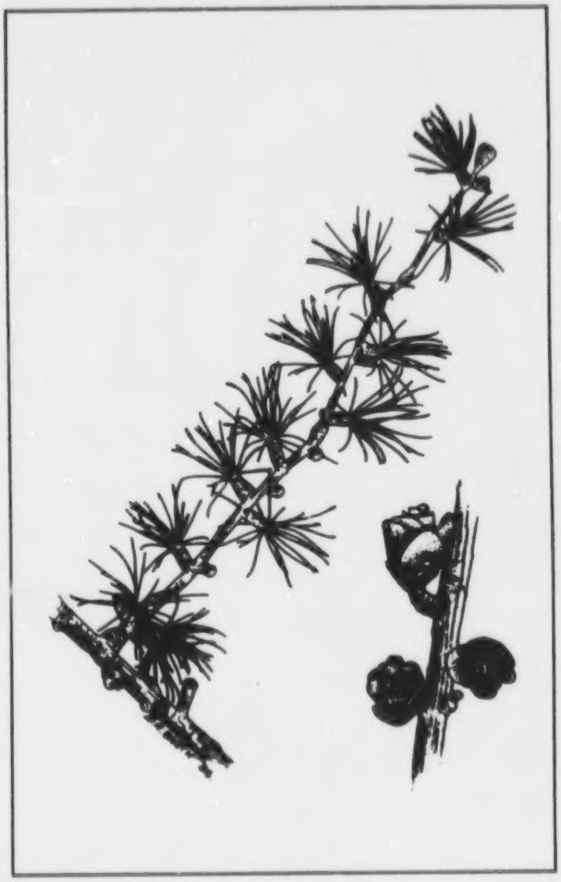
TOLERANCES

Soil Preferences

Tamarack is adapted to a range of soil moisture conditions from well drained through to poorly drained peat materials. It is also found on a wide range of soil textures (5). It produces the best growth on moist, light well-drained soils (205, 419).

Nutrient Requirements

Expected to have moderate to low nutrient requirements, based upon sites normally occupied.



Soil Reaction

Tamarack prefers neutral soils (pH 5.5 to 7.6) (P. Sims, pers.comm.), but has been reported to have high acid tolerance (5).

Soil Salinity

Not generally found on saline soils.

Drought

Generally not tolerant of drought.

Heavy Metals and Hydrocarbons

Tamarack was killed by a summer oil spill and no tree seedling establishment was observed 3 years after the spill. The effect of a winter spill was less severe. Tamarack was largely defoliated by a summer diesel oil spill but survival was quite high (216). No other susceptibilities or tolerances were noted from the literature reviewed.

Shade

Tamarack has very low shade tolerance; it requires well lighted situations and is rarely found in pure stands (5, 205).

Browsing - Cutting kills tamarack.

Susceptibility to Disease and Insect Damage

Tamarack is susceptible to needle cast, needle rust, "Amillaria root rot" and white pocket rot (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Tamarack has a relatively slow growth rate and slow cover rate (5). The root system is shallow, but widespreading so it is moderately windfirm (205). Tamarack was found to have a faster growth rate and provided a greater amount of litter than black spruce (P. mariana) when planted on coal mine spoil piles. This factor was considered important since additional organic matter improved the spoil water holding capacity (15).

Adaptation to Disturbance

Tends to re-establish rapidly on burned bogs and muskeg where nutrient supply is enhanced and also where shade from competing species is temporarily removed (T. Laidlaw, pers.comm.).

Competitive Ability

Good competitive ability on suitable sites. Grows best on upland sites but not common there, presumably partly because of low (seedling) competitive ability due to very low shade tolerance. It is recommended that tamarack plantings are not mixed with fast growing trees at normal planting densities, for the same reason (T. Laidlaw, pers.comm.).

Commercial Value

Tamarack produces durable, strong wood. It is used for railway ties, poles, boat building and pulpwood (443, 205). Tamarack has been used for reforestation (419).

Palatability and Nutritive Value

Not generally eaten by wildlife, although seed may be eaten by birds and small mammals. Sharp-tailed grouse have been observed eating tamarack buds.

Seed or Planting Stock Availability

Potential sources of native seed or stock are not known.

Methods and Ease of Establishment

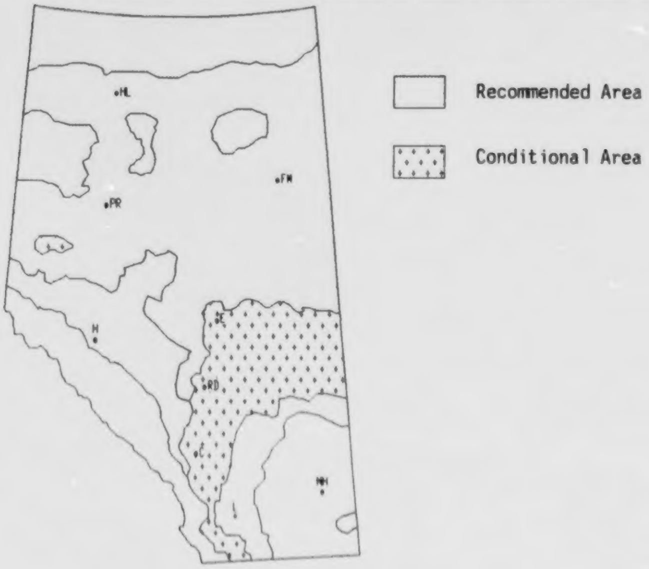
Tamarack can readily grow from seed. Cones are brown when ripe and can be collected in the fall as soon as they are ripe. Cones may be opened by heating at 49°C for 8 hours. In general, Larix seed may be stored for three or more years in sealed containers at -18 to 10°C. Seed germination requirements are variable, depending on seed source. Some seed lots may require cold stratification at 5°C for 30 to 60 days. Unstratified seed can be sown in the fall, or stratified seed sown in spring. Sow seed 0.6 cm deep (419, 119).

Current Status for Reclamation

Tamarack exhibited variable success on amended tailings sand at Fort McMurray. Survival varied from 0 to 60% (A. Fedkenheuer, pers.comm.). Siberian larch has potential on protected subalpine sites in Alberta. Survival after 8 years ranged from 50 to 85% and growth was the best of all species tested at two high elevation sites in Alberta (708). Tamarack is recommended for revegetation in southern Alaska on well-drained sites (5). Survival of spring-planted tamarack at the end of summer was very low in a trial on an abandoned winter road near Norman Wells, N.W.T. (110). Tamarack is a widely distributed species and ecotypes probably exist. Two year old seedlings from different seed sources in Minnesota had significant differences in height growth, and bud set occurred earliest in those seedlings from northern sources (419).

Picea glauca

SPECIES SUITABILITY MAP AND SUMMARY TABLE



HL
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☐ Recommended Area
▨ Conditional Area

Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance					X
pH Acid		4.5			
Tolerance Base					
Winter Hardiness		X			
Erosion Control				X	
Persistence		X			
Palatability		X			
Browse Tolerance				X	
Moisture Preference	Moist, tolerates flooding.				
Soil Preference	Silty, tolerates wide range of textures.				

Picea glauca (Moench) Voss

SPECIES BIOLOGY

Taxonomy - White spruce

Varieties: var. albertiana (S. Brown) Sarg. and var. porsildii (Raup); P. canadensis (Mill.) B.S.P.

Origin and Range

Native. Alaska east across Canada to Hudson Bay, Labrador, and Newfoundland, south to New York, Minnesota, Montana, and British Columbia. Also locally in South Dakota and western Montana (443, 419). The most common form in Alberta is western white spruce (Picea glauca var. albertiana (S. Brown) Sarg.). Another variety, Porsild spruce (P. glauca var. porsildii), is found occasionally from Banff northwards. This variety is characterized by smooth bark covered with resin blisters. White spruce also intergrades with Engelmann spruce (P. engelmannii) at middle altitudes in the Rocky Mountains (205, 312), and Sitka spruce (P. sitchensis) where ranges overlap, such as north coastal B.C.

Growth Habit

A medium to large sized tree 12 to 21 m high and 15 to 46 cm in trunk diameter. It may grow up to 40 m high in favourable sites with diameters of up to 120 cm (443, 205, 690). At the timberline it becomes a prostrate shrub (krummholz) (443). Slow growing (659).

Nitrogen Fixing

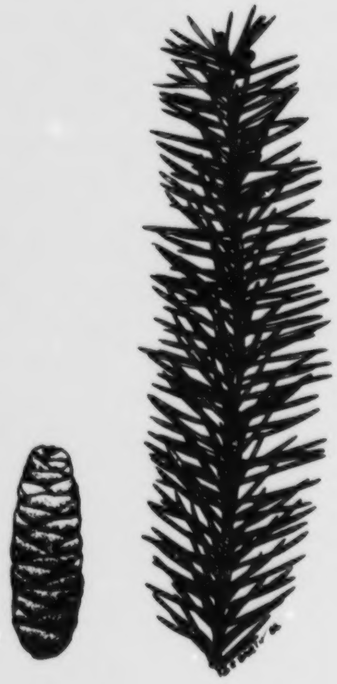
None. White spruce is ectomycorrhizal (622).

Longevity - Long-lived perennial.

Self Propagation - Seed (5).

Ecological Setting

White spruce is a widespread tree characteristic of the boreal forest region. It is found in a variety of habitats, but most commonly on well drained moist sites to the subalpine. It is rarely found in pure stands but is found in a mixture with other species. Common native associates (mixed-wood): Populus tremuloides, Abies balsamea, Betula papyrifera (205).



TOLERANCES

Soil Preferences

White spruce is adapted to well drained, somewhat dry soils through to soils that are poorly drained (5). It has best growth on well drained silty soils that have adequate available moisture (205). It occurs on a wide range of soil textures. White spruce can withstand flooding during the growing season (5).

Nutrient Requirements

Moderate (low to medium) (688) to "exacting" (659).

Soil Reaction

White spruce has high acid tolerance (5). The lower pH limit for white spruce has been reported to be 4.5 to 5.0 (346). However, seedlings grown in peat with pH adjusted (lime additives) from 3.9 upward to 5.0 had half the total weight and root weight of seedlings grown in peat of pH 3.9 (295).

Soil Salinity

White spruce is intolerant of saline conditions (229).

Drought

White spruce has proved to be moderately drought tolerant when planted on tailings sand in northern Alberta (A. Fedkenheuer, pers.comm.).

Heavy Metals and Hydrocarbons

White spruce has a moderate tolerance to oil (282). No other tolerances were noted from the literature reviewed.

Shade

White spruce has high shade tolerance, and can tolerate completely shaded conditions (5, 205, 346).

Browsing

Will regrow after minor amounts of pruning.

Susceptibility to Disease and Insect Damage

White spruce showed an adverse response after being planted on sites three days after glyphosphate spray application. There was no visible response when spruce was planted six days after the spray application (to control competing grasses) (99). White spruce is susceptible to needle rust, bad rust, snow blight, "Amillaria root rot" and brown cubicle rot (198). It is also susceptible to spruce sawfly and spruce gall aphid (P. King, pers. comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

White spruce has a shallow root system with many wide spreading lateral roots. It is only moderately resistant to windthrow (205). It has relatively slow initial height growth and slow cover rate (5).

Adaptation to Disturbance

Although primarily a climax species of the boreal forest region, it is commonly found on disturbed sites, especially where mineral soil has been exposed and there is a seed source nearby (365).

Competitive Ability

White spruce was found to compete successfully with perennial grasses and forbs after fertilization (99).

Commercial Value

White spruce is an important source of lumber and pulpwood in Canada (205).

Palatability and Nutritive Value

White spruce can be used on reclaimed sites to provide shelter for elk and mule deer (439). White spruce seed is a preferred red squirrel food. May be severely browsed by snowshoe hare.

Seed or Planting Stock Availability

Native seed and seedling stock is available commercially.

Methods and Ease of Establishment

Cones should be air dried for several weeks or in a kiln at temperatures of 38 to 49°C. White spruce seeds are damaged at higher temperatures. Seeds can be stored for long periods (75 years) at 1 to 3°C at moisture contents of 4 to 8%. White spruce seeds of some provenances can be germinated satisfactorily without any stratification. Seeds are fall sown at a depth of 0.6 cm. Most often stratified seed is sown in containers or spring sown in the field. Seedlings are usually outplanted as 2-0 stock (419).

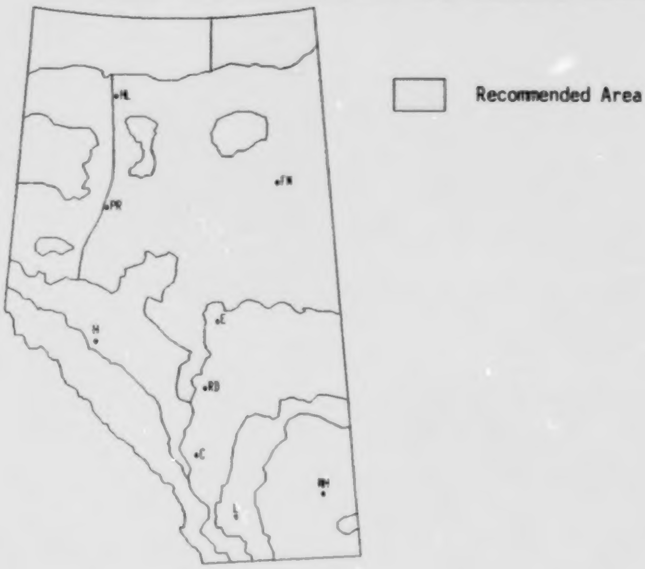
Current Status for Reclamation

White spruce is regarded by the Alberta Forest Service as the best reclamation conifer species on coal overburden in the eastern slopes (377). It is well adapted to the foothills to the lower subalpine with good potential for protected sites in the subalpine (707). Eighth year survival at Tent Mountain (2 100 m) was 76%. Susceptible to stem dieback on windy, high elevations sites (707). In the Crowsnest Pass area, bare root stock had higher survival than containerized stock (377). Other tests at Tent Mountain showed very good survival (P. King, pers.comm.). White spruce is well adapted to reclamation of amended tailings sand near Fort McMurray (645, 706). Performance in several tests after 4 to 7 years on amended tailings and overburden indicated moderately good to excellent survival, good growth, no dieback and a positive response to heavy ground cover

(J. Sherstabetoff, pers.comm., 641, 706). Survival and growth of white spruce at Elliot Lake, Ontario was found to be greater on vegetated coarse uranium tailings than on bare coarse tailings. The initial pH of the coarse tailings was 1.9 but this increased to between 3.5 to 4.0 as a result of leaching (317).

Pinus banksiana

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance					X
pH Tolerance Acid	3.5				
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Clay loam, sand and gravel, well drained.				

Pinus banksiana Lamb.

SPECIES BIOLOGY

Taxonomy - Jack Pine.

Origin and Range

Native. Jack pine is the most widely distributed pine species in Canada (615). It ranges from northeastern British Columbia and the Mackenzie River Valley in the Northwest Territories, southeasterly into the Great Lakes region and the New England States, running east into Nova Scotia and New Brunswick. In central and northern Alberta, hybridization occurs between jack pine and lodgepole pine (Pinus contorta Dougl.) where their ranges overlap.

Growth Habit

Jack pine has a conical, open crown and a slender, straight trunk with little or no taper. Heights range from 5 to 10 m on open or poor sites to 20 m on good sites. The root system is wide-spreading, moderately deep and without a tap root, except on deep porous soils (660). Medium growth rate (659).

Nitrogen Fixing

None. Jack pine is ectomycorrhizal (622).

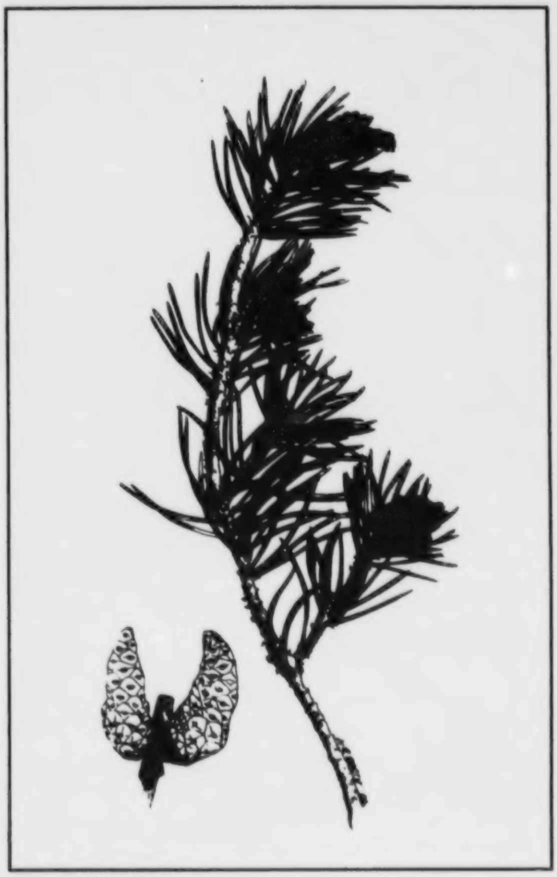
Longevity - Long-lived perennial.

Self Propagation

Jack pine has been rated as good for natural reproduction by reseeding on mineral soil prepared mechanically (scarification and slash redistribution) or by fire.

Ecological Setting

Characteristically jack pine is a tree of the boreal forest region (660). Most jack pine stands occur in areas characterized by warm to cool summers, very cold winters, low annual rainfall and level to rolling topography (615, 637). It grows in extensive, even aged pure stands or in a mixture with other species such as black spruce, white spruce, balsam fir, trembling aspen, balsam poplar and white birch. Jack pine usually occurs in a pioneer stage of succession; it will invade where mineral soils have been bared and as a result many stands establish after fire. However, on very dry, sandy sites in the southwestern portion of its range it may regenerate itself in the absence of fire (615).



TOLERANCES

Soil Preferences

Jack pine is found on a wide range of soil textures ranging from gravelly or sandy through to clay loams. It also occurs on relatively thin rock outcrop soils (615, 637). The soil moisture conditions vary from dry to moist and only infrequently does it occupy soils that are poorly drained. Its best growth occurs on moist upland, well drained sandy soils. Jack pine is adversely affected by the formation or presence of iron pans (615).

Nutrient Requirements

Jack pine survives on nutrient poor sites and has low nutrient requirements (610).

Soil Reaction

Generally jack pine makes reasonably good growth on soils with a pH of 4.5 to 6.5 (637), but a recent study has reported that jack pine has a high acid tolerance and success on very acid soil (pH 3.5). Jack pine does not grow naturally where the surface soil is alkaline, however it will grow satisfactorily on calcareous soils (pH 8.2) if normal mycorrhizal association is present (637).

Soil Salinity

None reported in the literature reviewed.

Drought

Jack pine is adapted to xeric sites (610, 637).

Shade

Jack pine is intolerant of shade (615). However, seedlings can exist in light as low as 2.4% of full sunlight (637), but more light is required for establishment. Under stands, jack pine seedlings are most frequent and abundant in light intensities of 11 to 30 % of full sunlight, but height growth is greatest in light intensities of 52% or more (653).

Browsing

Jack pine will sustain light to moderate browsing. Reduced growth, serious injury or death can result from moderate to heavy browsing pressure (637).

Susceptibility to Disease and Insect Damage

Susceptible to jack pine budworm (Choristoneura pinus), several sawflies (Empetria spp.), pine tussock moth (Dasychiia plagiata), northern pitch twig moth (Petrova albicapitana), white pine weevil (Pissodes strobi) and several caterpillars (Halisedota spp.) (637). Jack pine is also susceptible to a variety of rusts (198) such as spindle rust gall (Cronartium comandrae), globose rust gall (C. harkensii) and several needle rusts (Coleosporium spp.) (637). Dwarf mistletoe or witches broom (Areuthosium americanum) reduces vigour and is associated with considerable mortality (637).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Jack pine is fast growing with a shallow, wide spreading rooting system and is good for promoting soil stability.

Adaptation to Disturbance

Jack pine seedlings become quickly established on disturbed areas in its natural range.

Competitive Ability

Competition from other vegetation may adversely affect growth of seedlings, but once established jack pine seedlings and saplings can out-compete other vegetation.

Commercial Value

Jack pine is used for pulp and in general construction. Other uses include railroad ties, poles, pilings and mine timbers (660).

Palatability and Nutritive Value

Seedlings in particular may sustain heavy browsing pressure by snowshoe hare, porcupine and field mice. White-tailed deer, elk and moose will also browse jack pine during the winter months.

Seed or Planting Stock Availability

Native seeds and nursery stock are readily available. Seed yield averages 1 kg of seed per 100 kg of cones. There are approximately 288 200 clean seeds per kg on average.

Methods and Ease of Establishment

Jack pine may be established directly from seed or from transplants (bare root or container). Cones should be dried immediately after collection to avoid mold development and excessive internal heating. The cones are serotinous and need at least 50°C to open. They should be dried in a kiln for 5 to 6 hours at 77°C. Seeds can be stored for 10 years at -18°C at a moisture content of 5 to 10%. Jack pine seed may display embryo dormancy and can be cold stratified at 5°C for 0 to 7 days. The seeds can be sown in the spring or the fall to a depth of 0.6 cm. Seedlings can be out planted as 1-0 or 1.5-0 stock for easy to average sites, 1-1 or 2-1 stock for difficult sites (615). Recommended plant spacing is 1.5 m by 1.8 m. In one study over-wintered seedlings contained in Japanese paper pots out-performed bare root seedlings in terms of survival and growth. Good seedling establishment during the first and second years following scarification (733). Areas should be scarified the same year and slash left over the area to ensure large amount of seed available. May and June are the two most favourable months for germination and seedling establishment (733).

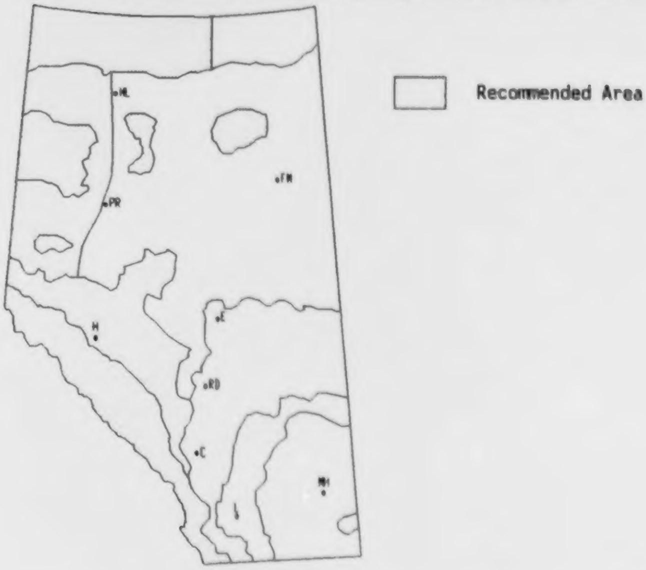
Current Status for Reclamation

Jack pine is fast-growing, adapted to xeric, nutrient poor sites found commonly on coarse to medium textured well-drained soils. It has done well in tests on amended oil sands and has been recommended for reclamation of lands disturbed in oil sand mining (610, 645). After seven years testing on amended tailings sands near Fort McMurray, jack pine had the highest survival, vigour and growth (706). At another site jack pine survival levelled off at 70% at four years. Competition from ground cover appeared to reduce survival (641).

Jack pine survival rates on gravel pits after 15 years was 78% in Appalachia. Jack pine has performed quite well on mine spoil in a variety of conditions, however a drastic growth reduction was noted at 15 years. Survival rates on strip-mined soils after 2 years were: sand 59%, sandy loam 84%, stony clay 94%.

Pinus contorta

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING				
		Very High	High	Medium	Low	None
Drought Tolerance			X			
Salt Tolerance					X	
pH Tolerance	Acid		X			
	Base			X		
Winter Hardiness			X			
Erosion Control			X	X		
Persistence			X			
Palatability				X	X	
Browse Tolerance				X		
Moisture Preference		Dry to moist.				
Soil Preference		Well drained loamy soil. Tolerates wide range of texture (gravelly to silty clay loam) and drainage.				

Pinus contorta Loudon

SPECIES BIOLOGY

Taxonomy - Lodgepole Pine

Variety: var. latifolia Engelm.

Origin and Range

Native. Lodgepole pine ranges from Alaska east to the southwestern Mackenzie region and south through western Alberta and British Columbia; also in the Rocky Mountains to Colorado and Utah (443).

Growth Habit

Lodgepole pine is the larger form, and has a narrow crown. It is usually between 15 and 33 m in height, and 20 to 60 cm in diameter (443, 205).

Nitrogen Fixing

None. Lodgepole pine is ectomycorrhizal (622).

Longevity - Long-lived perennial.

Self Propagation

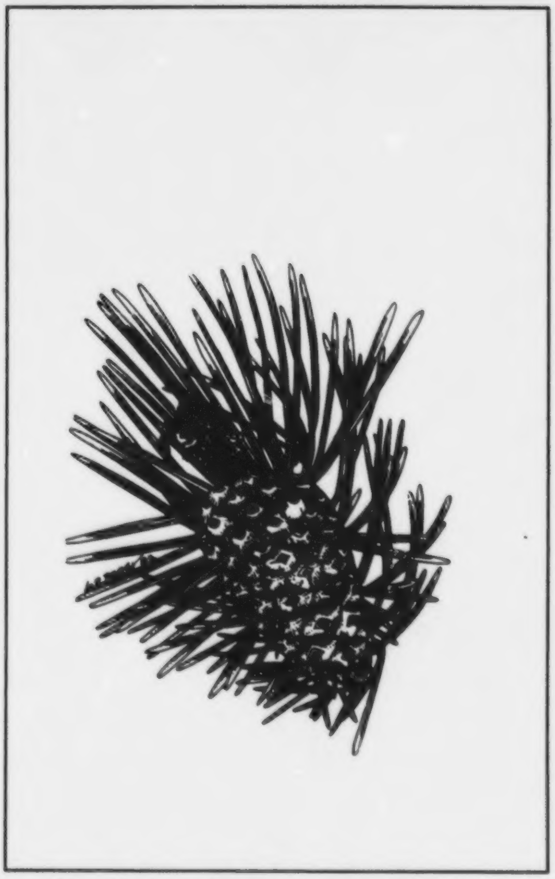
Lodgepole pine has been rated as good for natural reproduction by reseeding (5, 358).

Ecological Setting

In Alberta, lodgepole pine is the most common tree species on the eastern slopes of the Rocky Mountains. It ranges from the lower foothills and montane zones into the upper subalpine. It also extends eastward to about Lesser Slave Lake in central Alberta. Lodgepole pine intergrades with jack pine (Pinus banksiana) where their ranges overlap in central and northern Alberta. It commonly forms pure stands after fire. It is found on a wide variety of sites from dry outwash gravels and sands to swampy areas (443, 205, 312).

TOLERANCES

Soil Preferences



Lodgepole pine is found on a wide range of soil textures from very gravelly sands to silty clay loam (5). It is also found in a range of soil moisture conditions from well drained soils with low water holding capacity to poorly drained soils (5). It achieves its best growth on well drained loamy soils (205).

Nutrient Requirements

Lodgepole pine invades very infertile sites. Plantings made on coarse, infertile soils in Colorado were reported to be successful (44).

Soil Reaction - High acid tolerance (5).

Soil Salinity - Generally not tolerant of saline soils.

Drought

One of the most drought tolerant of our native conifers. It is often successful on dry, or otherwise severe, sites due to its ability to survive where its less tolerant competitor trees succumb.

Heavy Metals and Hydrocarbons

Moderately tolerant of oil spills. Other tolerances are not known.

Shade

Lodgepole pine is intolerant of shade and does not appear to reach light saturation even at light intensities of 12 000 foot candles (356).

Browsing

Will regrow following moderate hedging.

Susceptibility to Disease and Insect Damage

Susceptible to pine bark beetle, in even aged mature stands, and lodgepole pine sawfly (Ips pini). Susceptible to a variety of rusts and dwarf mistletoe (P. King, pers.comm.). Generally few pests.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Lodgepole pine has a moderate height growth rate and a slow cover rate (5, 338). It has been rated as very good for promoting soil stability (338). The long slender form of this species makes it susceptible to wind throw.

Adaptation to Disturbance

Lodgepole pine seedlings become quickly established on disturbed areas within its natural range (302, 338, 365).

Competitive Ability

Lodgepole pine had improved growth on plots scalped or sprayed for surface weed control compared to control plots (99). Results at Fort McMurray and Grande Cache, Alberta indicate that lodgepole pine can compete with grass if minimum moisture requirements are satisfied (269, 641).

Commercial Value

The wood of lodgepole pine is used for construction lumber and pulp. It is also used for railway ties, poles, mine timbers and locally for fuel (443, 205).

Palatability and Nutritive Value

Lodgepole pine has been reported to be lightly consumed relative to other plants during winter, summer and fall and moderately consumed in spring by mule deer (245). Important wildlife food for squirrels, chipmunks, grosbeak and Clark nutcracker (608). It is commonly known to support some forest furbearers; seedlings, in particular, may sustain heavy browsing pressure by snowshoe hare.

Seed or Planting Stock Availability

Native seed is available (349) and nursery stock is common. Approximately 202 000 seeds/kg (639). Seed yield averages 0.8 to 1.0 kg of seed per 100 kg of cones.

Methods and Ease of Establishment

Lodgepole pine may be established directly from seed or from transplants (5, 283, 427, 451). Cones should be dried immediately after collection to prevent mold and excessive internal heating. The cones are serotinous and can be opened by immersion in boiling water for 30 to 60 seconds and then air drying for 2 to 30 days (this technique may be effective for small lots, but is not used operationally by nurseries). Seed can be stored at 5 to 10% moisture content at -18 to -15°C for long periods. Lodgepole pine seed displays embryo dormancy and can be cold stratified at 5°C for 30 to 50 days. Seeds can be sown in the fall, or spring sown after stratification. Sow seeds 0.3 cm below the soil surface. Seedlings can be outplanted as 2-0 stock (119, 419). Maximum plant spacing has been recommended as 3 m by 3 m (5). Lodgepole pine had a better survival rate in Hillson (164 cm^3) and Tinus (492 cm^3) containers compared to the smaller Ferdinands (40 cm^3) and Fives (80 cm^3). Some damage to seedlings has been noted where the tops were exposed during a low snowfall year (271).

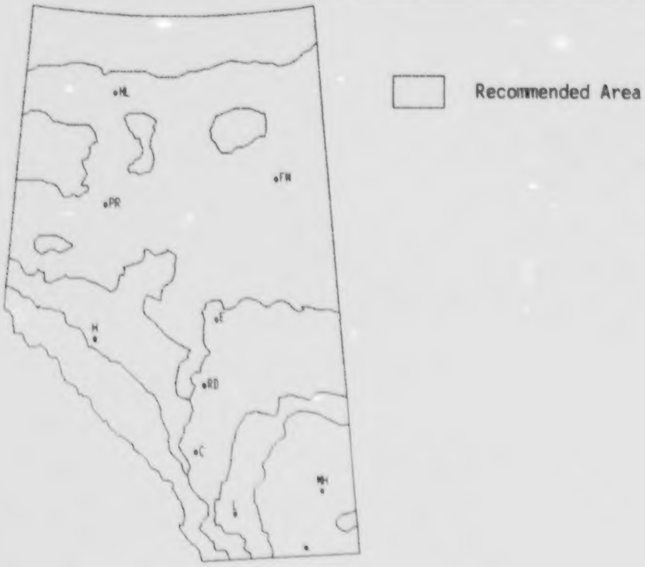
Current Status for Reclamation

Lodgepole pine has potential for reclamation in the oil sands region near Fort McMurray (645). Survival on amended tailings sand ranged from 50 to 70% after 3 to 4 years and from 70 to 80% on clay to clay loam overburden (A. Fedkenheuer, pers.comm., 641). Growth averaged 12 cm/year over the first four years on amended tailings (641). Elsewhere in Alberta, lodgepole pine is a widely used forestry species, and undergoes systematic collection, propagation and planting by the Alberta Forest Service. It is also commonly used for reclamation of all types of disturbances throughout the Rocky Mountain east slopes where its range extends into the lower subalpine (707). Growth rate and survival after ten years was at least twice as great when lodgepole pine was planted on 30 or 70 cm of topsoil versus planting directly on overburden on the Judy Creek test mine in northwestern Alberta (642).

Lodgepole pine planted in tar paper plots had excellent survival (greater than 80%) in the subalpine in Colorado (451, 16). Lodgepole pine has been recommended for planting on disturbed sites in the subalpine in northwestern Colorado. The soils in this area are shallow, often rocky and low in fertility (427). On high altitude sites or severely eroded sites in New Zealand, lodgepole pine showed fair to good growth. On exposed high altitude sites, the upright growing lodgepole pine was prone to bark abrasion from windborne ice and stones. Limited seeding of lodgepole pine was only successful where soil conditions were already fair to good (203). Lodgepole pine is also used in reclamation in the United Kingdom (331).

Populus balsamifera

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X	X		
Browse Tolerance		X			
Moisture Preference	Moist to wet, tolerates flooding.				
Soil Preference	Wide range from silt, sand to gravel.				

Populus balsamifera L.

SPECIES BIOLOGY

Taxonomy - Balsam Poplar

Subspecies: ssp. balsamifera and ssp. trichocarpa (T. and G. ex Hook.)

Origin and Range

Native. Alaska east across Canada to Labrador and Newfoundland, south in the eastern United States to West Virginia, Indiana and Iowa and in the western mountains south to Colorado (443, 419). It hybridizes with black poplar (P. trichocarpa Torr and Gray) where their ranges overlap (443, 690).

Growth Habit

Balsam poplar is a medium-sized deciduous tree usually 9 to 25 cm in height and 30 to 70 cm in diameter. It may occasionally reach heights of over 30 m and diameters greater than 140 cm (443, 205).

Nitrogen Fixing - None

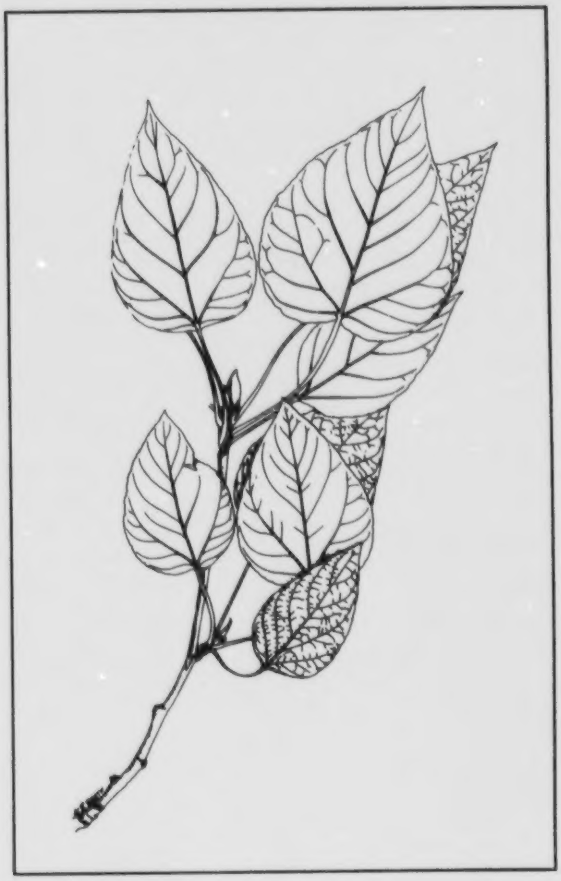
Longevity - Long-lived perennial.

Self Propagation

Balsam poplar reproduces from seed. If the tree is cut or destroyed by fire, it will resprout from the stringers or roots. Branch segments also have the ability to take root (5).

Ecological Setting

Balsam poplar is common along river banks, river valleys, terraces, and gravelly flood plains. In Alberta, it is common throughout the forested region especially in openings and clearings on moist upland sites. It is found on wet sites throughout the prairies. In Alberta, its range extends into the subalpine. Common native associates (river bottom land): Alnus tenuifolia, Cornus stolonifera, Viburnum edule, Rosa acicularis and Rubus strigosus. On upland sites, balsam poplar is successional with the climax being white spruce or balsam fir (443, 205, 78, 399).



TOLERANCES

Soil Preferences

Balsam poplar is adapted to a range of soil moisture regimes from well drained through to poorly drained soils that may be waterlogged for short periods. It is also adapted to a range of soil textures (5). It does best on moist, low-lying ground (205).

Nutrient Requirements

Requires moderate amounts of nutrients; low to high (688). These are usually available on the moist, low sites it favours.

Soil Reaction

Balsam poplar has a low acid tolerance (5). "Cottonwood" has been designated as suitable for planting on alkaline or saline soils (421).

Soil Salinity

Balsam poplar has poor growth and survival on saline spoil materials near Edmonton, Alberta (304).

Drought

Balsam poplar does best on sites where moisture stress is minimal.

Heavy Metals and Hydrocarbons

Balsam poplar was killed by a diesel spill near Whitehorse, N.W.T. (216). No other chemical sensitivities were noted from the literature.

Shade

Shade tolerance is rated from low (5) to medium (P. Sims, pers.comm.).

Browsing - Resprouts readily after cutting.

Susceptibility to Disease and Insect Damage

Balsam poplar is susceptible to leaf spot, leaf blight, leaf rust, powdery mildew, sooty bark canker, "Amillaria root rot", white spongy rot and brown mottled root rot (198). It is also susceptible to Cytospora canker which can cause serious damage to cuttings in nurseries and can kill shelterbelt trees in 2 to 3 years. Insects potentially damaging to balsam poplar include forest tent caterpillar, western tent caterpillar, poplar and willow borers, and oyster shell scales.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Balsam poplar has a relatively rapid height growth rate and a medium cover rate (5). It has a shallow root system (205), and a taproot in some situations (466).

Adaptation to Disturbance

Balsam poplar has been noted as a volunteer on mine overburden in British Columbia (316). It has also been noted as a pioneer on mine spoils in Alberta (357). It is apparently an aggressive pioneer on moist disturbances throughout the eastern slopes of the Rocky Mountains (365). Typical early colonizer of sand and gravel pits in Ontario (688).

Competitive Ability

Very aggressive in adapted areas. Cottonwood cuttings planted on a disturbed mine area in southeastern B.C. had good survival and growth even though the area had a good grass cover (P. King, pers.comm.).

Commercial Value

The wood is light, soft and not very strong. It is used for plywood, pulpwood and crates. A small amount is used for lumber. Balsam poplar is commonly used as a windbreak on the prairies (443, 205). It is also useful for providing cover and forage for game (180), especially in early successional phases (688).

Palatability and Nutritive Value

Extensively used by beaver. May occasionally be used by other wildlife. Susceptible to rodent damage (385). Young trees and new growth are often taken by browsers.

Seed or Planting Stock Availability

Seed is not commercially available; onsite collections of locally adapted ecotypes is the preferred method of acquiring seed.

Methods and Ease of Establishment

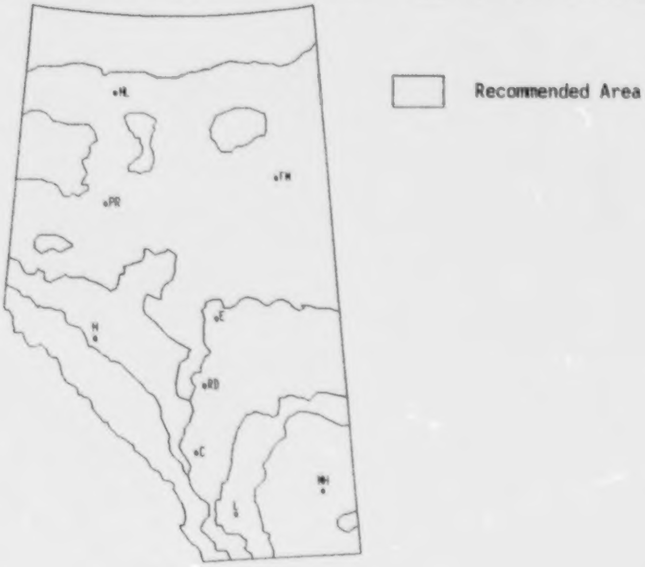
Balsam poplar produces abundant seed almost every year. Small catkin-bearing branches can be picked when a few of the catkins are beginning to open. These can be laid out to dry to allow the remaining catkins to open. Seed can be cleaned by tumbling the seed with cotton in an air stream in covered standard soil screens. The seed is tumbled in the uppermost screen (16 mesh) and is collected on the lower screens (32- and 150-mesh). Seed can be stored for relatively long periods at a moisture content of about 6%, and at temperatures below 0°C. Seeds require moist conditions for favourable development. They should not be covered or pressed into the soil. Seedling root development is initially very slow so care must be taken not to wash the seedlings out of the soil when watering the plants (419). Other methods of establishment are seedling transplants, root cuttings and stem cuttings. The recommended method is hardwood stem cuttings planted at a maximum spacing of 1.5 m x 1.5 m (180, 5). In a trial in northern Alberta, 59% of balsam poplar stem cuttings produced roots (149). Seed has been found to be as successful as stem cuttings as a method of propagation (A. Fedkenheuer, pers.comm.).

Current Status for Reclamation

"Northwest" poplar, a hybrid of balsam poplar, has been recommended for reclamation of oil sands materials (645). "Northwest" hybrid was the best poplar after six years (tallest, largest stem, highest vigour and lowest dieback) on amended tailings sand near Fort McMurray. Survival after four years on amended tailings sand was 60 to 70% under moderate to heavy ground cover. Growth of the container stock averaged 14 cm/year during this period (641). Tests in Alberta indicated that "Northwest" and balsam poplar are not suited for subalpine and lower subalpine regions. While initial survival of "Northwest" was acceptable (66% at 2 years), long term (8 year) survival was very low (1%) due to stem dieback and heavy browsing (272, 271, 671, 707). Hardwood cuttings planted as unrooted poles had poor survival (15%) when planted on sand dunes near Lesser Slave Lake, northern Alberta (258). Balsam poplar has been used successfully for reforestation in the forested zone of Alberta up to 1 230 to 1 540 m ASL. In general, direct planted cuttings require more moisture and have slower growth in the initial years after planting than rooted cuttings (272). "Northwest" poplar planted as bare root stock had good survival and were vigorous on amended natural sands near Fort McMurray (A. Fedkenheuer, pers.comm.).

Populus tremuloides

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Acid				X	
Tolerance Base			X		
Winter Hardiness		X			
Erosion Control		X			
Persistence	X	X			
Palatability		X	X		
Browse Tolerance		X	X		
Moisture Preference	Moist.				
Soil Preference	Wide range of sandy, gravel loam soils; well to imperfectly drained.				

Populus tremuloides Michx.

SPECIES BIOLOGY

Taxonomy - Trembling Aspen.

Origin and Range

Native. Trembling aspen is the most widely distributed tree in North America. It ranges from Alaska east across Canada to Labrador and Newfoundland, south in the northeastern United States to New Jersey, Virginia, and Missouri and south in the western mountains to northern Mexico and southern California (443, 419). Hybridization occurs between many species of North American poplar where their ranges overlap and also between North American and European poplars (419).

Growth Habit

A slender, small to medium-sized deciduous tree, trembling aspen averages 13 to 20 m in height and 20 to 25 cm in diameter. It may attain heights of 30 m and diameters of 60 cm (443, 205). The growth rate of F1 hybrids between *P. tremula* and *P. tremuloides* is greater than either of the parents (419, 372).

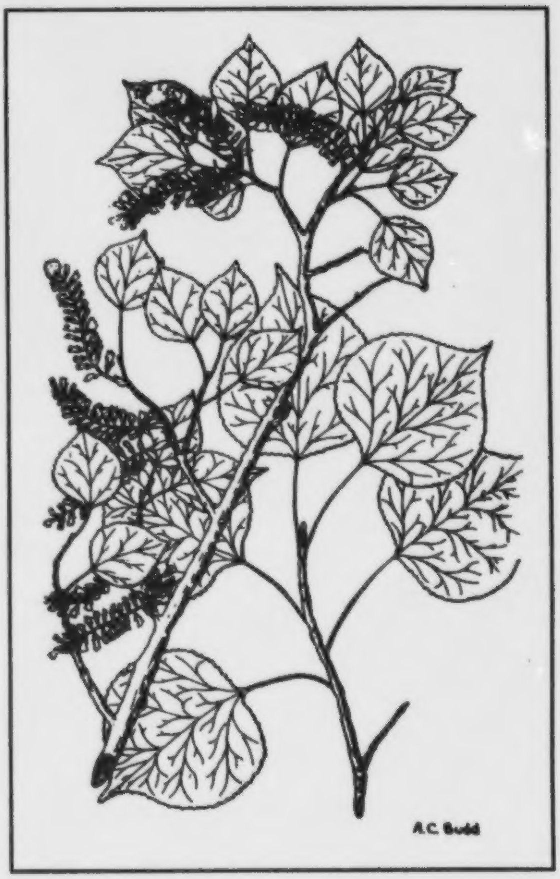
Nitrogen Fixing - None

Longevity

A long-lived perennial. Growth of trembling aspen will continue until stands are aged 80 to 100 years, after which they begin to deteriorate (443).

Self Propagation

Trembling aspen reproduces occasionally by seed and root suckers (30, 275). Often clones of considerable size are produced as a result of sucker development (205). Suckering is not significant in undisturbed forest but is very vigorous when sites have been disturbed by burning or clear cutting. Sucker development is largely the result of increased soil temperature (275), but removal of apical dominance is also important.



Ecological Setting

Trembling aspen is an ubiquitous component of northern forested regions in Canada. It often occurs in pure stands as a result of fires where it acts as a "nurse tree" to various softwoods. These eventually replace trembling aspen in dominance resulting in the mixed-wood and mature softwood stands characteristic of the boreal forest. Trembling aspen is also common throughout the prairie in bluffs and around sloughs. These bluffs interspersed with prairie give rise to the aspen parkland zone between northern forest and prairie (205), 64). It is found on dry, sandy slopes to the upper subalpine (501, 365). Common native associates: *Populus balsamifera*, *Betula papyrifera*, *Picea glauca* and *Abies balsamea*, with *Pinus banksiana* or *P. contorta* on the drier sites.

TOLERANCES

Soil Preferences

Trembling aspen is found on a wide range of soils from well drained through to poorly drained soils. It is also found on a wide range of soil textures (5). It does best on well drained, moist, sandy or gravelly loam soils (205).

Nutrient Requirements

Trembling aspen may grow in relatively poor soils. On open, dry, outwash plains they often grow as low plants in single groups and wherever the terrain (but not always the soil quality) becomes more favourable they reach tree size (372). Low to medium fertility requirements (659, 688).

Soil Reaction

Trembling aspen has been reported as having low acid tolerance (5). However, it has been observed as a successional species on flat barren sand areas near Sudbury, Ontario. The soils there are very acidic (pH 3.2 to 4.5) (28). The optimum pH range for hybrid aspen (P. tremula x P. tremuloides) planted on tailings sand in the Netherlands has been reported to be between 4.0 and 5.1 (372).

Soil Salinity

Trembling aspen had poor survival on sodic mine spoils at Wabamun, Alberta (304).

Drought

Trembling aspen trees are moderately resistant to drought (248).

Heavy Metals and Hydrocarbons

Trembling aspen trees were killed by diesel oil spills presumably by the effects of the oil on the root systems (316). It has been observed as a pioneer species on acid barren sands with elevated levels of Cu, Ni and Al (28).

Shade

The species is shade intolerant. High light intensities (about 3 500 foot candles) are required for minimum photosynthesis (356, 248).

Browsing

Late-season heavy browsing has been suggested as a means of controlling the encroachment of aspen suckers onto prairie grasslands (24). It must therefore be concluded that heavy browsing will at least control rate of spread by killing new sucker growth.

Susceptibility to Disease and Insect Damage

Trembling aspen is susceptible to leaf spot, leaf rust, shoot blight, sooty bark canker and "Amillaria root rot" among others (198); insects such as the forest tent caterpillar and poplar borer are also damaging. The seedlings are susceptible to mildew and damping off (248).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control

The root system is shallow and wide-spreading (205). Roots commonly produce root suckers, often a considerable distance from the parent tree and in this way invade grassland and disturbed sites. Suckers have been observed up to 32 m from the parent tree (40). It has been rated as very good in promoting soil stability (338) and is considered a "soil-improving species" (659).

Adaptation to Disturbance

Trembling aspen encroaches on "old fields", and has spread in the prairies since prairie fires have been suppressed (64, 469). It will invade prairies in the absence of heavy grazing (browsing) or mowing and where moisture is sufficient (40). Expands by root suckers into areas where seedling establishment would be difficult because of competition from grasses (40). Suckers may also be produced where surface soil temperatures are unfavourable for seedling development (275). Trembling aspen is a pioneer on mine spoils in Alberta (33) and British Columbia (384). Typical early colonizer of sand and gravel pits in Ontario (688).

Competitive Ability

Trembling aspen can spread by suckers through established grassland (248). However, production of aspen suckers was lower in a disced and seeded plot compared to a disced and unseeded plot. The aspen suckers competed less successfully with the seeded grasses than other woody plants such as snowberry (Symphoricarpos sp.) and wild rose (Rosa sp.) (24).

Commercial Value

Trembling aspen is mainly used for pulpwood, chipboard ("aspenite"), veneer and plywood (205); also valuable for erosion control and game forage (120), and general cover in early successional stages (688).

Palatability and Nutritive Value

Trembling aspen is palatable to both deer and livestock (40, 245). Utilization of trembling aspen was rated as high by bighorn sheep, elk and moose, and medium by mule deer in the foothill ranges of Alberta (144).

Seed or Planting Stock Availability

Aspen seed is available, and seedlings and cuttings are fairly easy to collect or acquire. Many hybrids and cultivars are commercially available.

Methods and Ease of Establishment

Small catkin bearing twigs should be stripped from the tree when the catkins are on the point of dehiscence (or when the seeds are a light straw colour). These should then be spread out to dry which will result in the eruption of seed and "cotton" in a few days. Seeds need not be separated from the cotton which may provide a light mulch for the delicate seedlings. However, if seed is to be stored or used in container growing, the cotton should be removed as with balsam poplar (P. King, pers.comm.). Seedlings require high light intensity for establishment. Seeds have no embryo dormancy and freshly collected seed usually has a high rate of germination (95 to 100%). Seed can be stored for up to a year in a dessicator at 04°C. Seeds should be sown on sterile substrate and kept moist and warm (12° to 20°C) (248, 419). Unlike other poplars, trembling aspen can not be easily established from stem cuttings (30, 120, 499). It can be successfully propagated from root cuttings or green cuttings taken from suckers (275, 499). The process to produce sucker cuttings is as follows: Root cuttings (2.5 cm to 8 cm in diameter and 20 cm long) are treated with a fungicide, their ends are dipped in paraffin and then planted in moist vermiculite or coarse sand.

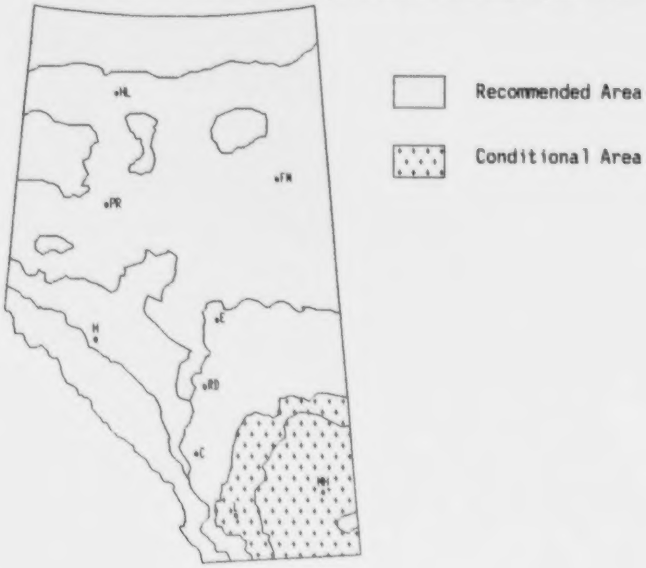
Suckers develop in 25 days to 6 weeks depending on temperature and humidity conditions. The bases of the sucker cuttings (3 to 10 cm long) are then treated with IBA (Indole-3-buteric acid) and planted directly in a moist rooting medium in containers. The suckers develop roots in 2 to 3 weeks after planting. Cuttings must be rooted in high humidity conditions. Root cuttings may be collected in fall or spring. There is clonal variation in suckering and rooting ability (30, 499, 371). Misting of the seedbed with Captan and sulphur discourages damping off and mildew (248). Establishment of trembling aspen in the field directly from seed, has not been tried often. Sometimes established in Europe by laying catkin-bearing branches on the ground and covering them with a plastic sheet. It has been rated as good for establishment of transplants and seedlings. Plant spacings have been recommended as 1.6 m by 1.7 m (5, 338, 419).

Current Status for Reclamation

Survival of trembling aspen on amended tailings sand in northern Alberta was variable. Greatest survival was recorded on plots where grass and legume cover was least. This suggests that during early establishment, trembling aspen can not compete with grasses for moisture, particularly during dry years (149). Plantings on amended tailing sand had low survival after 7 years, however this may be attributable to poor planting stock (706). In operational plantings trembling aspen third year survival was 85% with a sparse ground cover but annual growth was relatively poor (10 cm versus 35 cm for "Northwest" poplar") (645). Plantings in the alpine region of Alberta (Tent Mountain) had 52% survival after eight years. However, due to stem dieback and heavy browsing plant height averaged only 16 cm (708). This species is moderately resistant to drought, can grow in nutrient poor soils, and can easily be propagated by means of root cuttings. It has a wide geographical distribution and is found on a range of soil moisture regimes and soil textures. Trembling aspen is also fast growing and once established spreads vigorously by means of root suckers. It has great potential for reclamation purposes in Alberta but further research is needed into genetic variability of this species. There is the possibility that clones could be developed which are suitable for specific site conditions.

Potentilla fruticosa

SPECIES SUITABILITY MAP AND SUMMARY TABLE


HL
FM
PR
E
H
RD
C
MH
Recommended Area
Conditional Area

Commercially Available: Yes X No__

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid		4.5			
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability				X	
Browse Tolerance			X		
Moisture Preference	Moist, tolerant of flooding.				
Soil Preference	Sandy to loamy, fair on clay.				

Potentilla fruticosa L.

SPECIES BIOLOGY

Taxonomy - Shrubby Cinquefoil.

Also Pentaphylloides floribunda (Pursh) A. Love.

Origin and Range

Native. Alaska across Canada to Labrador, Newfoundland and Greenland. South to New Jersey, Iowa, New Mexico and California. Also across Europe and Asia. Many cultivars available (443).

Growth Habit

Many-branched shrub 0.3 to 1 m high; deciduous (443).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Propagates both by seed and by root sprouts (5). Rated as moderate for both natural reseeding and natural vegetative reproduction (338).

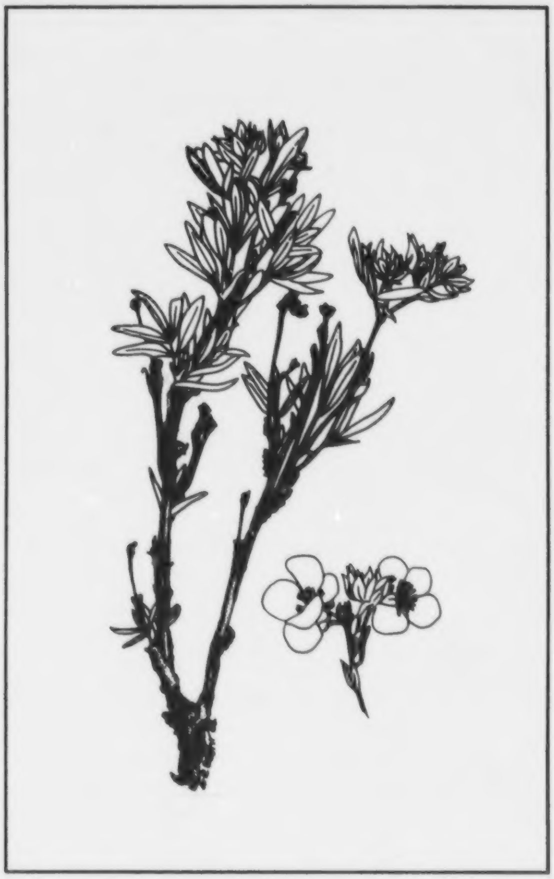
Ecological Setting

Found in a wide range of habitats, from prairie to alpine. In the Cypress Hills and foothills region of southern Alberta, it is found in low moist situations. Occurs in the boreal forests of northern Alberta where it is largely confined to swamps and borders of streams. In the mountains, it is found on dry rocky ledges and in open valley bottoms, and it is present in subalpine dwarf birch-willow communities (78, 690, 429, 428). Common native associates (muskeg): Salix bebbiana, Betula glandulosa, Ledum groenlandicum, Larix laricina, Picea glauca, Andromeda polifolia.

TOLERANCES

Soil Preferences

Shrubby cinquefoil is found on a wide range of soil conditions from well-drained through to poorly drained soils (5). Good growth reported on sandy and loamy soils with only fair growth on clayey soil (446). In Alaska, it has been rated as tolerant of wet conditions and flooding (5).



Nutrient Requirements

Shrubby cinquefoil is reported to grow well on low nutrient tailings sand amended with mineral fines and fertilizer in northern Alberta (149).

Soil Reaction

Shrubby cinquefoil has high acid tolerance; it can tolerate soils with pH below 4.5 (495). It is sometimes found occurring naturally in acid bogs (5). Also found on calcareous substrata (332, 136).

Soil Salinity

No specific tolerances noted from the literature, but is expected to be relatively intolerant of saline conditions.

Drought

Moderate (5) to good drought tolerance (A. Fedkenheuer, pers.comm.).

Heavy Metals and Hydrocarbons

In a field study near Norman Wells, N.W.T. Potentilla fruticosa was killed by oil but reinvaded spill sites after 3 to 4 years. A simulated diesel oil spill largely defoliated the plants but they resprouted (216). Seedlings survived planting on a very acid (pH 3.2) coarse textured soil which was high in Al at a site near Dixonville, Alberta (434).

Shade

Slightly tolerant of shade; it prefers open sites but will grow under light shade (356).

Browsing - Can tolerate moderate browsing (430).

Susceptibility to Disease and Insect Damage

Susceptible to vole damage when planted on tailings sand with grasses, but less so than other woody shrubs (A. Fedkenheuer, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

It has a moderate cover rate with a fibrous root system (5). Optimum slope for establishment has been reported as 9 to 30% (446). Rated as moderate for erosion control (447) and soil stabilization.

Adaptation to Disturbance

Rare individuals reported to have invaded coal spoil piles at Cadomin, Alberta (1 675 m ASL) where severe climatic limitations exist (wind and drought) (358). Reported as pioneer species on glacial outwash of the Muldrow Glacier (pH 8.0 to 8.4), Alaska (322). In southern Alberta, it is often found on open, grassy slopes where its presence is regarded as evidence of overgrazing. Invades disturbed areas when a seed source is nearby (365). Rated moderate in adaptation to disturbance (338). Potentilla tridentata, a related species, was found to invade tailings sand in northern Alberta (J. Sherstabetoff, pers.comm.).

Competitive Ability

Shrubby cinquefoil exhibited moderate vigour on plots subject to moderate grass competition and grasshopper infestation. Seedlings failed completely on plots subject to severe grass competition (102). The species invades and persists on overgrazed grasslands (due to its generally low palatability) and often must be controlled.

Commercial Value

Ornamental (378), erosion control (447).

Palatability and Nutritive Value

Low palatability; grazed by goats (domestic) but not sheep (domestic) (136); lightly browsed by mule deer (245) and bighorn sheep in the alpine tundra (225). Observed to be browsed by elk on winter ranges in Alberta.

Seed or Planting Stock Availability

Shrubs and seedlings are available at high cost from nurseries.

Methods and Ease of Establishment

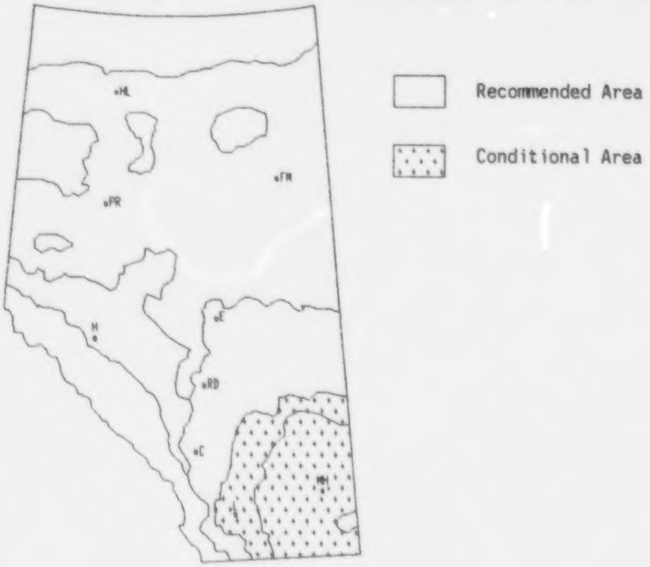
Seed, seedlings and transplants (5), and hardwood cuttings (149). The seed is easily propagated in containers. Germination rate is reported to be 53 to 82% (121). Seeds ripen over a wide time span so that individual collections may be prone to low viability (J. Sherstabetoff, pers.comm.). Seed should be planted as soon as ripe. Seed is reported to be the best method of establishment (A. Fedkenheuer, pers.comm.). The maximum spacing for planting seedlings is recommended to be 1.2 m by 1.2 m (5). Wild plants transplant easily, as do bare root nursery stock (480, 337). Moist soil is needed for direct seeding. Seedlings are durable and persistent once established (480).

Current Status for Reclamation

Initial evaluation at the Upper Colorado Environmental Plant Centre rated Potentilla fruticosa as good for revegetation of disturbed lands in the subalpine, and good for roadside stabilization and beautification. It was rated very good for restoration of processed oil shale wastes, and fair for wildlife habitat improvement (266). It shows excellent survival as container seedlings on amended tailings sands in northern Alberta (121). It has been successfully used for revegetation of high altitude (3 150 m to 4 120 m ASL) lands disturbed by mining in Colorado (73). Recommended for revegetation in interior Alaska (5). Has been rated as providing fair cover for mule deer and good cover for game birds and small mammals (447). Survival on amended tailings sand was negatively affected by ground cover. Third year survival was 20% in dense versus 96% in sparse ground cover (645, 667).

Prunus virginiana

SPECIES SUITABILITY MAP AND SUMMARY TABLE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Recommended Area
Conditional Area

Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid			X		
pH Tolerance Base			X		
Winter Hardiness			X		
Erosion Control		X			
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Moist.				
Soil Preference	Loamy, well to moderately well drained.				

Prunus virginiana L.

SPECIES BIOLOGY

Taxonomy - Choke Cherry.

Origin and Range

Native. Newfoundland to British Columbia, south to southern California, New Mexico, Kansas, Illinois, Maryland and south to Georgia. Many cultivars available (419, 205, 78).

Growth Habit

A shrub or small tree 0.6 to 6 m high. In favourable circumstances, it may reach a size of up to 10 m high, with a diameter of 15 cm (205, 312).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Primarily by seed, some suckering. Natural vegetative reproduction has been rated as very good and natural reseeding as moderate (338).

Ecological Setting

Common throughout the prairies in open situations along riverbanks, fence lines, and bordering wooded areas. It is found throughout the boreal forest in open situations. In northern parts of its range it is usually found on drier south-facing slopes. In the central Rocky Mountains, it is found in moist situations at elevations between 1 500 and 2 600 m (426). Common native associates: Rosa acicularis, Populus tremuloides, Alnus crispa (205, 312, 78).

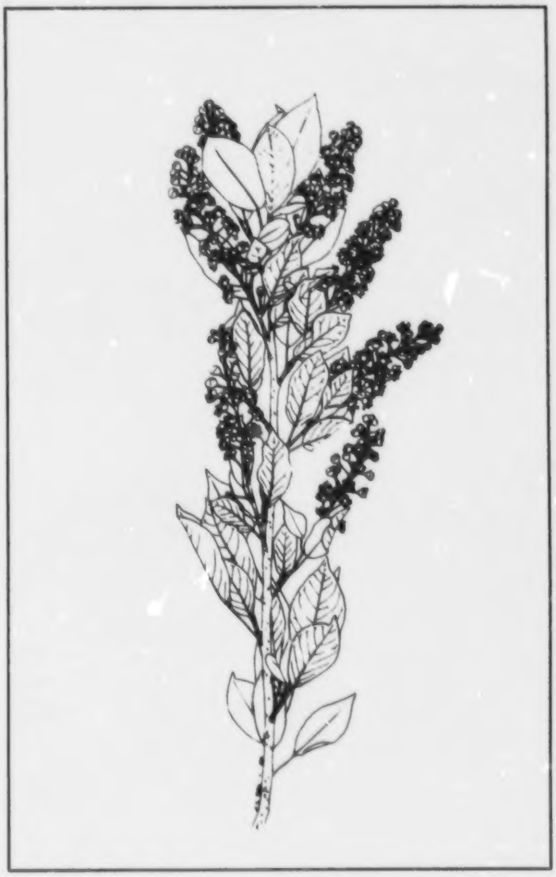
TOLERANCES

Soil Preferences

Prefers moist soil conditions with loamy soil textures. It is commonly found on rich moist soils (205). However, reported as accepting dry to mesic sites in Ontario (688). Reported to grow best in areas receiving at least 40 cm mean annual precipitation (426).

Nutrient Requirements

Moderate requirements; medium to high (688).



Soil Reaction

Choke cherry is adapted to soils that are moderately acidic to moderately alkaline (338).

Soil Salinity

Moderately tolerant of slightly saline soils.

Drought

Variously rated as: not tolerating excessive moisture stress (426); moderate to good with respect to drought tolerance (A. Fedkenheuer, pers.comm.); and, drought tolerant (608).

Heavy Metals and Hydrocarbons

No information available.

Shade

Choke cherry is relatively intolerant of shade (205).

Browsing

Will resprout from root crowns. Tolerates moderate browsing.

Susceptibility to Disease and Insect Damage

Choke cherry saplings were found to be girdled by meadow voles and white-tailed deer mice on tailing sand dyke in northern Alberta (345) (J. Sherstabetoff, pers.comm.). Diseases include black knot and western X disease (P. King, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Choke cherry has a good growth rate and has been rated as very good for soil stability (338).

Adaptation to Disturbance

Choke cherry has been rated as very good for adaptation to disturbance (338). It is found almost exclusively on disturbed sites in northern Alberta (A. Fedkenheuer, pers.comm.).

Competitive Ability - Not particularly aggressive.

Commercial Value

Ornamental, used as windbreak in prairies; wildlife food (419), especially winter browse (688). Berry picking; historically, used in preparation of pemmican (205).

Palatability and Nutritive Value

Foliage may contain hydrocyanic acid under drought stress or after frost (221). High frequency of browsing and moderate intensity of browsing by deer and elk reported in southeastern B.C. (393). Suggested to be moderately palatable to wild game and occasionally poisonous to sheep and cattle (205). Excellent for wildlife plantings (608, 639).

Seed or Planting Stock Availability

Many cultivars available from commercial nurseries. Predominantly ornamental shrub stock. Native seed is also available. Approximately 10 560 seeds/kg (639); approximately 40 to 55 kg seed per 100 kg fruit is produced.

Methods and Ease of Establishment

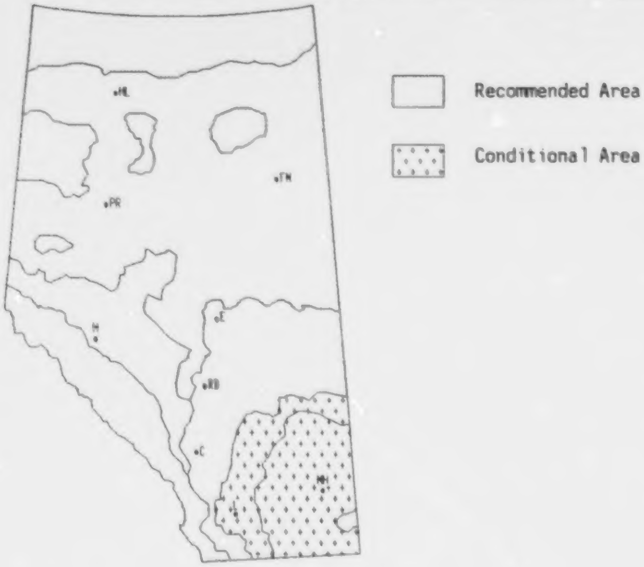
Fruit should be collected when fully ripe (red-purple to dark purple)(419). Seed has embryo dormancy. Cold stratify at 5°C for 120 to 160 days or sow in the fall. Sow seeds 1.0 cm deep (391). Seed should be subjected to weight separation as it can be heavily infested with worms (149). Direct seeding on tailings sand in northern Alberta was unsuccessful. However, field germination has been reported to be good at 2 000 m ASL in Colorado (397). Seeds can be stored at -18°C (434). It is regarded as moderately difficult to germinate because of its hard seed coat. Warm storage of seed at high moisture contents even for only a few months will be harmful to seeds (419). Other methods of establishment for Prunus sp. are budding, grafting, suckers and root cuttings (21).

Current Status for Reclamation

Field tests have indicated that choke cherry has potential for reclamation in the oil sands. Third-year survival ranged 50 to 65% with moderate to heavy ground cover. Growth rate was comparable to other tall shrubs (645). Choke cherry underwent extensive testing in Saskatchewan before being recommended for shelterbelt plantings there (207). Commonly used in the northern and central great plains for windbreaks, soil stabilization and wildlife plantings (426). Choke cherry has been rated as good for establishment by transplants and moderate for establishment from seed (338). Black choke cherry has been used for revegetation of road sides and other disturbed or eroded areas in Utah (336).

Rosa acicularis

SPECIES SUITABILITY MAP AND SUMMARY TABLE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Recommended Area
Conditional Area

Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid		X			
pH Tolerance Base					
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance			X		
Moisture Preference	Moist to wet, tolerates flooding.				
Soil Preference	Wide range, well to imperfectly drained.				

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Rosa acicularis Lindl.

SPECIES BIOLOGY

Taxonomy - Prickly Rose.

Subspecies: ssp. sayi (Schiv.) also R. bourgeauiana Crepin.

Origin and Range

Native. Alaska to Labrador, south to West Virginia, Minnesota, New Mexico, Idaho and British Columbia. It is also widespread across northern Eurasia (443). Hybridization with R. woodsii common in Alberta (J. Packer, pers.comm.).

Growth Habit

A low bushy shrub 0.5 to 1.5 m in height. May grow to 2.5 m in the shade (78, 312).

Nitrogen Fixing

The species does not fix atmospheric nitrogen (331). No rhizosheath was observed on this species in a survey of vegetation on sandy, disturbed sites in Alberta (P. Lulman, pers.comm.).

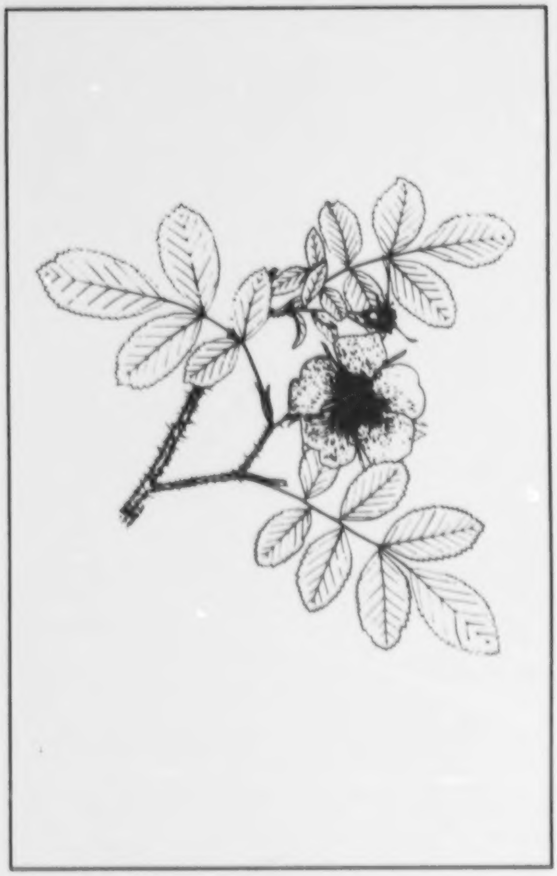
Longevity - Long-lived perennial.

Self Propagation

Seeds take two years to germinate naturally. Seeds develop and mature the first growing season, warm stratify the next growing season (and the fruits decompose), cold stratify the following winter and germinate in the spring after snowmelt. Prickly rose also spreads by rhizomes to form clones. Root sprouts form when the plant is destroyed by fire or is cut (5, 121).

Ecological Setting

Prickly rose is found throughout the boreal forest region. It is especially common in the shaded undergrowth of mixed wood and deciduous forests. It occurs on old burns, in bogs and along roadsides. It is also found on river banks, in bluffs and in fields throughout the prairies where it is associated with Rosa woodsii and R. arkansas. Common native associates (mixed wood): Populus tremuloides, Picea glauca, Ribes triste, Viburnum edule, Rubus strigosus.



TOLERANCES

Soil Preferences

Prickly rose is adapted to a range of soil moisture regimes from well drained through to poorly drained soils. It can withstand flooding during the growing season, and is found on a wide range of soil textures (5).

Nutrient Requirements

Prickly rose has been reported as a pioneer on gravel and silt bars of the Cheena River, interior Alaska. The gravel is low in nutrients and susceptible to rapid freezing and thawing (442).

Soil Reaction

Prickly rose has high acid tolerance (5).

Soil Salinity

Rosa spp. were found to be less common on disturbed sites where the soil was high in sodium (332).

Drought

Prickly rose has moderate drought resistance (5). It has been found to have good drought tolerance on amended tailings sand in northern Alberta (A. Fedkenheuer, pers.comm.).

Heavy Metals and Hydrocarbons

Prickly rose has been noted as moderately tolerant to crude oil (216). No other tolerances have been found in the literature examined.

Shade - It is moderately tolerant of shade (5).

Browsing

The stems are covered with straight bristles which may discourage excessive browsing (78). The plant will resprout from the roots if cut or killed by fire (5).

Susceptibility to Disease and Insect Damage

Prickly rose is susceptible to various leaf rusts, leaf spots, powdery mildew, stem canker and crown gall (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

It has a rapid cover rate and spreads by rhizomes (5, 149).

Adaptation to Disturbance

Wild rose (Rosa acicularis/Rosa woodsii) are common on disturbance sites throughout the eastern slopes of the Rocky Mountains. They often invade disturbed bare areas, especially where mineral soils are exposed (365). Prickly rose has been reported as a pioneer on river gravel heaps (236) and burned areas (458). It invades disturbed sandy sites in northern Alberta (J. Sherstabetoff, pers.comm.).

Competitive Ability

Wild rose (Rosa acicularis/Rosa woodsii) had only 20% lower density in a plot disced and seeded with grass, compared to a disced and unseeded plot in a field experiment near Edmonton, Alberta. They were quite effective at competing with the seeded grasses (24).

Commercial Value

Rose hips are rich in vitamin C. They are used to make jellies, jams and ketchup (443); ornamental; wildlife food (120, 443). Provincial flower of Alberta.

Palatability and Nutritive Value

Prickly rose is browsed by mule deer (245). An ash content of 4.7% has been reported for samples collected in the Mackenzie Delta region, N.W.T. (403). Rose hips are eaten by grouse and other birds during fall and winter (443), and are noted to be high in vitamin C.

Seed or Planting Stock Availability

Seedlings may be available for reclamation research purposes from the Provincial Tree Nurseries.

Methods and Ease of Establishment

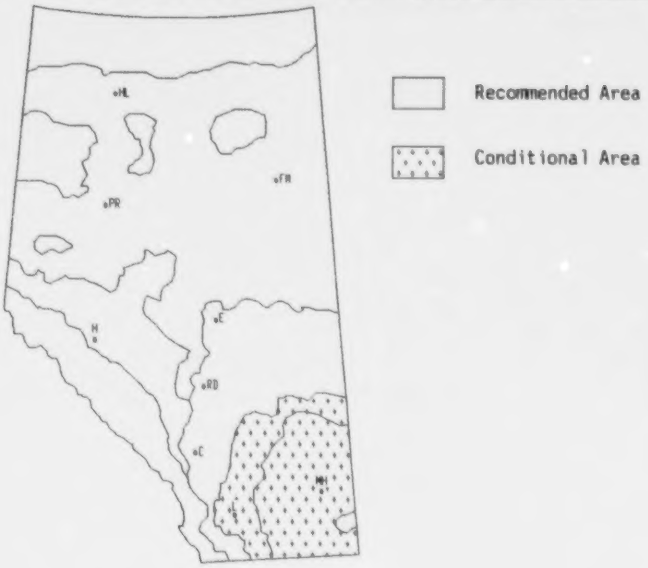
Seed can be collected in the fall. Warm stratify at 20 to 27°C for 60 to 90 days, then cold stratify at 2 to 5°C for 90 to 120 days. Either warm stratify and sow in the fall, or fully stratify and sow in the spring. Sow seeds 0.6 to 1.8 cm deep (119). Root cuttings, and hardwood and softwood cuttings have apparently been used successfully (194). Upper stem (hardwood) cuttings gave poor results in northern Alberta, however. Best results are from bare stem cuttings about 15 cm long which include 8 cm of the top of the root (149).

Current Status for Reclamation

Prickly rose is a variable species (443) adapted to a wide range of moisture regimes and soil textures. Among its natural assets for reclamation are its tolerance of acidic conditions and its shade tolerance which may exceed common wild rose (Rosa woodsii). The large genetic variability of this species suggests that suitable ecotypes may be selected for use on specific undisturbed sites. Excellent survival has been obtained on amended tailings sands in northern Alberta, however vigour was low (199, 641, 706). Rosa spp. are currently used for reclamation purposes in Denmark (331) and have been recommended for revegetation on moist to wet sites in Alaska (5).

Rosa woodsii

SPECIES SUITABILITY MAP AND SUMMARY TABLE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Recommended Area
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Commercially Available: Yes_X_ No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid			X		
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control		X	X		
Persistence		X			
Palatability		X	X		
Browse Tolerance		X			
Moisture Preference	Moist.				
Soil Preference	Wide range.				

Rosa woodsii Lindl.

SPECIES BIOLOGY

Taxonomy - Common Wild Rose; Woods Rose.

Also R. fendleri Crepin., R. macounii Greene, R. ultramontana Heller.

Origin and Range

Native. British Columbia to Western Ontario and Minnesota, south to Missouri, Nebraska, Arizona, and northern Mexico (419). It is the most widespread and common rose in Alberta (690).

Growth Habit

A tall bushy shrub 0.3 to 2 m in height (78, 312). Its form is highly variable. Fast growing (608).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Common wild rose spreads naturally by seeds and rhizomes (78).

Ecological Setting

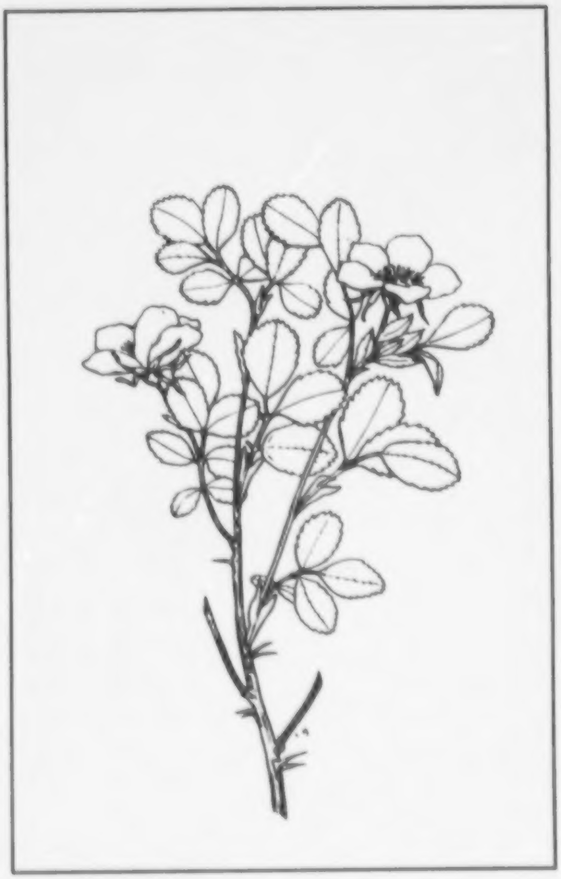
Common wild rose is found on bluffs, dry grassy slopes and on sandhills throughout the prairies. It is also found on riverbanks and clearings in the boreal forest to the subalpine. It is commonly found growing with R. acicularis in wooded areas and R. arkansas on the prairies (78, 312, 501).

TOLERANCES

Soil Preferences

Common wild rose is adapted to a wide range of soil types and good growth has been reported on a wide range of soil textures. It can withstand dry conditions but prefers moist soil (446). Rosa spp. were more abundant on coarse and very coarse textured soils compared to other soil textures on disturbance sites in Alberta (332).

Nutrient Requirements



Rosa woodsii seedlings planted on road cutbanks and fills at various sites in eastern Washington had a high rate of survival after two years, but vigour was fair to poor. Many of the plants appeared chlorotic, indicating higher nutrient requirements than other shrubs planted (415).

Soil Reaction

Common wild rose tolerates soils that are moderately alkaline to moderately acidic (338). It has been suggested as a useful species for revegetation on high pH and high lime soils (332).

Soil Salinity

Rosa spp. were found to decrease in abundance on disturbed sites where spoil materials were high in sodium (332).

Drought

Common wild rose has moderate drought tolerance.

Heavy Metals and Hydrocarbons

No specific tolerances noted. Expected to react as R. acicularis (c.f.).

Shade

It prefers open sites, but will grow under light shade (356).

Browsing

Common wild rose has a fairly high tolerance to browsing as thorns discourage over-browsing. Thorniness is highly variable.

Susceptibility to Disease and Insect Damage

Common wild rose is susceptible to various leaf spots, as well as to leaf rusts, gray mold, powdery mildew, common gall and stem canker (249).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

As for most roses, common wild rose is thicket forming, providing a dense soil cover. It has been rated as good for soil stabilization (470). Wood's rose (Rosa woodsii var. ultramontana) has been rated as very good for natural spread by vegetative means (rhizomes) (470). Growth rate is regarded as moderate (470).

Adaptation to Disturbance

Wild rose (Rosa acicularis/Rosa woodsii) is common on disturbance sites throughout the eastern slopes of the Rocky Mountains. It is especially prevalent along roadsides and south-facing cutbanks (365). Rosa spp. were found to invade nutrient deficient, coarse textured soils in the subalpine in Colorado (395). Common wild rose is rated as very good in its adaptation to disturbance (337). It is a common species on disturbed sandy sites in northern Alberta (J. Sherstabetoff, pers.comm.).

Competitive Ability

Wild rose (Rosa acicularis/Rosa woodsii) decreased in density by only 20% in a plot disced and seeded with grass compared to a disced and unseeded plot in a field experiment near Edmonton, Alberta. The roses were quite effective at competing with the seeded grasses compared to other forbs and woody plants (24).

Commercial Value

Rosa spp. are useful for erosion control and as wildlife forage (180). The hips of Wood's Rose (Rosa woodsii var. ultramontana) are used for flavouring teas, jellies and puddings. They are rich in vitamin C (480). Useful for ornamental and hedge plantings (608).

Palatability and Nutritive Value

Moderate use of common wild rose has been reported for mule deer and elk (144, 245). It has high palatability (38). It has been rated as providing good cover for mule deer and small mammals, and fair cover for game birds. It is a good food source for game birds and small mammals and a fair food source for mule deer (446), livestock and big game from spring through to fall (480). Important for winter food for wildlife (639) and game and non-game birds (608).

Seed or Planting Stock Availability

Native seed is available at moderate cost from American dealers. Approximately 45 300 seeds/lb (639). There are approximately 23 000 cleaned seeds per kilogram of fruit.

Methods and Ease of Establishment

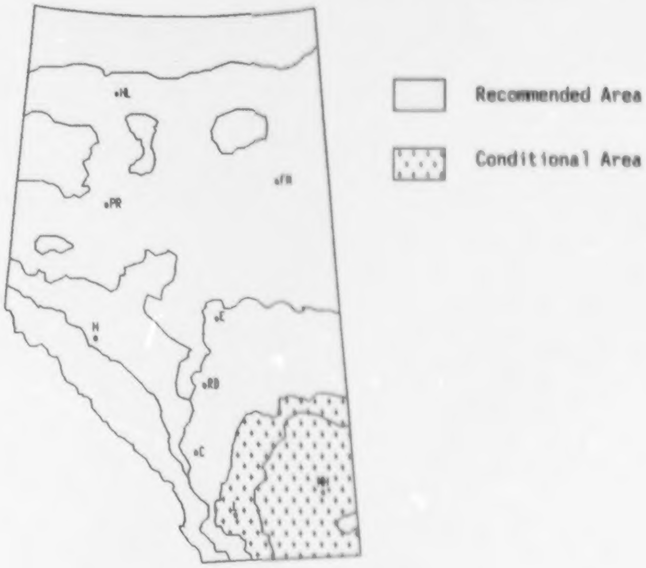
Collect seeds in the fall. Seed has seedcoat dormancy and requires warm stratification followed by cold stratification. Either warm stratify and sow in the fall or cold stratify and sow in the spring (194). Seed viability ranged from 44 to 64% for seed collected in northern Alberta (J. Sherstabetoff, pers.comm.). Germination outdoors takes about 30 to 40 days (293). The species is also readily established by hardwood tips and bare root cuttings (hardwood and root), budding, suckers, layering and grafting (21, 480). Transplants are also successful (337). Best establishment on nutrient deficient sites can be obtained from hardwood cuttings or nursery stock (338, 302).

Current Status for Reclamation

A row seeding trial and a broadcast seeding trial were totally unsuccessful on a harsh site at Tent Mountain, Alberta after the first growing season. Seed, however, was not pre-treated (380). Woods's rose (Rosa woodsii var. ultramontana) did poorly on amended tailings sand near Fort McMurray. While survival was high, vigour was low, and insect defoliation and dieback was high (706). Good results with hardwood cuttings have been obtained in Idaho where Rosa spp. are used for watershed plantings and erosion control. Wood's rose has been used by state and federal agencies for watershed plantings in Utah (302). It has also shown very good results in direct seeding and transplanting trials on clay soils in the subalpine in Utah. It was noted as a promising species for providing wildlife cover on high elevation ranges (337). Wood's rose has been recommended as a shrub species with low establishment requirements suitable for long term rehabilitation of juniper-pinyon woodland in northwestern Colorado. Here it is best suited to moist sites at an optimum slope of 9 to 30% (446).

Rubus idaeus

SPECIES SUITABILITY MAP AND SUMMARY TABLE



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Recommended Area
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Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance		X	X		
Salt Tolerance			X		
pH Tolerance Acid			X		
Base					
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability			X	X	
Browse Tolerance			X		
Moisture Preference	Moist to dry.				
Soil Preference	Silty clay loam to sandy loam, well to imperfectly drained.				

Rubus idaeus L.

SPECIES BIOLOGY

Taxonomy - Wild Red Raspberry.

Includes R. strigosus Michx. and R. melanolasius Focke.

Origin and Range

Native. A variable species with many geographic strains. Many commercial cultivars. Alaska to Newfoundland, south to North Carolina, Iowa, Arizona, California and northern Mexico. Related varieties extend across northern Europe and northwestern Asia (443).

Growth Habit

Deciduous bushy shrub 0.6 to 2.0 m high. Stems covered with prickles (78, 690).

Nitrogen Fixing - None

Longevity

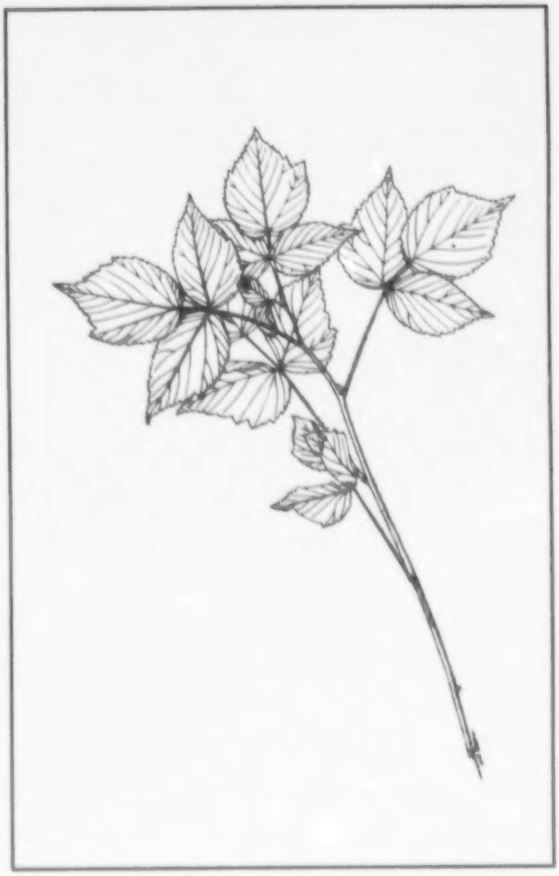
Long-lived perennial shrub with biennial stems (canes) (312). Several population samples of Rubus idaeus subsp. strigosus were collected in British Columbia and northern Alberta and significant differences in winter hardiness were noted among the samples (437).

Self Propagation

Wild red raspberry spreads by seed, root sprouts and stolons (5, 443).

Ecological Setting

Widespread throughout the boreal forest in clearings, at edges of woods, and on burnt areas. Found on bluffs and along riverbanks throughout the prairies. Also a roadside weed. It may be present on rocky screes or talus slopes above timberline (501). Common native associates (mixed-wood): Ribes triste, Rosa acicularis, Viburnum edule, Cornus stolonifera, Populus tremuloides, Picea glauca (443, 78, 690, 399).



TOLERANCES

Soil Preferences

Found on soils that are poorly, imperfectly and well drained, and with textures ranging from sandy loam to silty clay loam (5). Best suited to moderately well drained soils, where moisture is available.

Nutrient Requirements

Rubus spp. grow well on barren and infertile soils (419); low to high fertility needs (688).

Soil Reaction

Wild red raspberry has moderate acid tolerance (5). Rubus idaeus volunteered on previously barren, acid tailings sands that had been ameliorated with lime. This vegetation later deteriorated as the soil acidity increased again (from pH 4.8 to 3.9) (372).

Soil Salinity

Will probably tolerate moderate salinity.

Drought

Wild red raspberry is found on soils that have a tendency to be droughty (5).

Heavy Metals and Hydrocarbons

Has volunteered on lean tar sands in northern Alberta (J. Sherstabetoff, pers.comm.).

Shade

It has low shade tolerance (5).

Browsing

Will resprout from root crowns if cut late in the season.

Susceptibility to Disease and Insect Damage

Native Rubus spp. are generally well adapted to indigenous diseases and pests. Resistant.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Wild red raspberry forms thickets and has a rapid cover rate (443, 5).

Adaptation to Disturbance

Seedlings volunteered on a mixture of tailings sand and surface soil at an oil sands extraction plant in northern Alberta (257). Wild red raspberry is common on all disturbance sites in the eastern slopes of the Rocky Mountains in Alberta. It is apparently most vigourous on moist sites, or mineral soil and brush piles where it is often associated with fireweed (Epilobium angustifolium) (365). Common invader of disturbed sites including amended tailings sands and roadsides in northern Alberta (J. Sherstabetoff, pers.comm.).

Competitive Ability

Wild red raspberry was found to be unsuccessful at competing against grasses in an experiment near Edmonton, Alberta. Plant density decreased by 88% on seeded plots compared to unseeded plots (24).

Commercial Value

Cultivars are grown for the berries, which are eaten fresh or used in jams and jellies (437, 443).

Palatability and Nutritive Value

Fruit and young shoots eaten by wildlife. Thorns prevent excessive use.

Seed or Planting Stock Availability

Availability of native seed is not known. Cultivars are grown commercially for berry production from canes (stem cuttings).

Methods and Ease of Establishment

Seeds may be extracted by macerating the fruit in water, then floating-off or screening-out the pulp and empty seed. Seed can be stored at approximately 5°C for at least a year. The seed should be dried before storage. R. idaeus will germinate after cold stratification for 120 days or longer. Rubus strigosus has a hard seed coat and germination may be improved with scarification with sulphuric acid for 20 to 60 minutes or with a 1% solution of sodium hyperchlorite (419). Seed viability ranged from 92 to 99% for six seed lots collected in northern Alberta (J. Sherstabetoff, pers.comm.). Other methods of establishment include stem cuttings, root cuttings, layering and suckers (21).

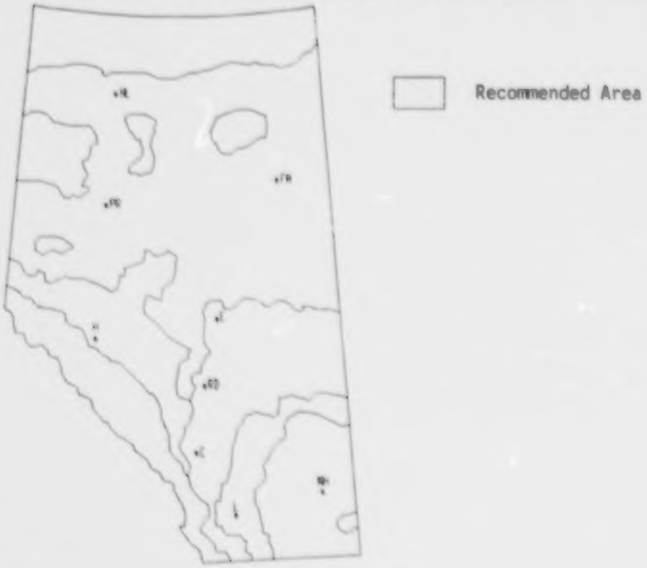
Current Status for Reclamation

Suitability of various ecotypes for reclamation purposes needs to be examined. Recommended for revegetation on well drained sites in the interior Alaska; maximum spacing suggested was 1 m by 1 m (5). Regarded as a pioneer for revegetating bare soils in the subalpine in Colorado (323). Wild red raspberry has been used successfully to stabilize roadcuts and disturbed areas in Utah (336).

Wild red raspberry is a variable species common on most disturbed sites in Alberta. It forms dense thickets and has been used successfully for erosion control. It is somewhat drought tolerant and can grow on infertile, bare mineral soil. This species has good potential for erosion control and revegetation on disturbed sites throughout Alberta. Research is needed into genetic variability of this species. It is easily established from stem cuttings, root cuttings and transplants. However, it cannot compete with grasses.

Salix arctica

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance				X	
pH Tolerance Acid					
Base			X		
Winter Hardiness	X				
Erosion Control				X	
Persistence		X			
Palatability			X		
Browse Tolerance			X		
Moisture Preference	Moist to dry.				
Soil Preference	Loamy to sandy loamy.				

Salix arctica Pallas

SPECIES BIOLOGY

Taxonomy - Arctic Willow.

Includes var. araioclada (Schneid.) Raup.

Origin and Range

Native. Alaska east across northern Canada, south in the mountains to Quebec and California. Also in northern Europe and Asia. Variable species, often sub-divided into several species (389).

Growth Habit

A depressed or low trailing shrub. Frequently forms dense mats 20 to 25 cm high (443, 312, 12). Variable in growth habit (443).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation - By seed and branch rooting.

Ecological Setting

Found throughout tundra and mountainous areas of Alaska. Arctic willow is found on both dry and wet sites; and in protected and unprotected situations. In southeastern Alaska it is sometimes found at sea level on glacial outwash and moraines (389). In Alberta, arctic willow is largely confined to the mountains; it is common at high elevations (312).

TOLERANCES

Soil Preferences

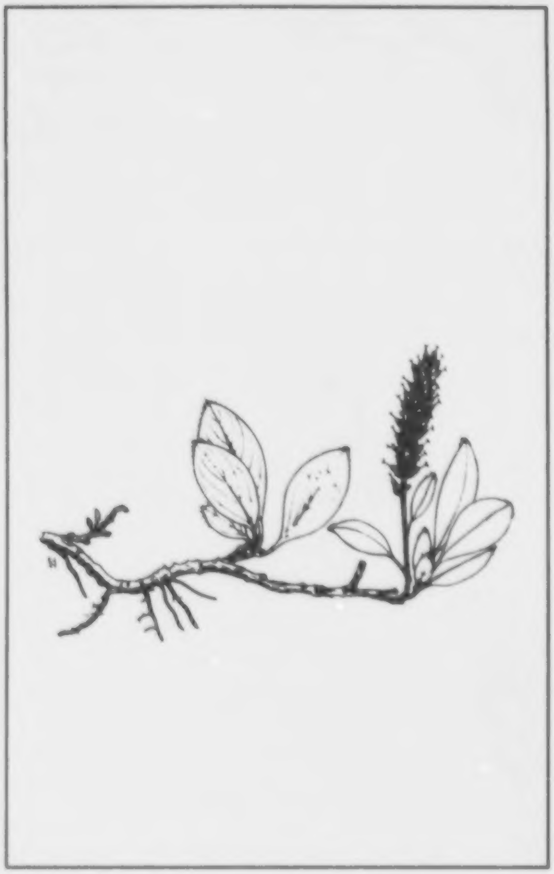
Observed on loamy to sandy loam soils. Generally on Regisols and alpine Brunisols. Appears to do best on very poor soils, although this may reflect poor competitive ability on sites which are favourable for grass and sedge growth.

Nutrient Requirements

Nutrient requirements expected to be low due to the type of site this species is usually found on.

Soil Reaction

Arctic willow often invades calcareous glacial moraines (332), and is therefore expected to somewhat favour pH's in excess of 7.0.



Soil Salinity

Would not be expected to tolerate saline soils.

Drought

Grows on sites which are subject to some moisture stress, or drought.

Heavy Metals and Hydrocarbons

Willows, in general, have been reported to have high tolerance for oil (282). No other tolerances have been noted.

Shade - Will not grow in shady situations.

Browsing

Regrows after browsing by bighorn sheep (225), and is known to be extensively browsed on the arctic tundra. This, plus the fact that these shrubs are notably slow growing, suggests moderate tolerance to browsing pressure.

Susceptibility to Disease and Insect Damage

Various diseases have been reported to infect arctic willow. These include black rib, leaf spot, tar spot, shoot blight, twig blight, soft white rot, and pitted sap rot (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

A slow growing species (22), that probably provides little protection from soil erosion.

Adaptation to Disturbance

Arctic willow invades disturbed dry sites in the Canadian high arctic, although it does not become established until much later than grasses (23). It was found to be an important colonizer of an abandoned airstrip on Ellesmere Island, N.W.T. where it comprised 30 to 40% of the ground cover compared to 5 to 10% in the undisturbed area (46). Arctic willow is a pioneer on glacial moraines at Glacier Bay, Alaska and near Clachnacudainn Snowfield, B.C. (332).

Competitive Ability

Thought to be a good competitor on harsh sites, but poorer than grasses in less severe locations.

Commercial Value

No commercial value, beyond forage value for wildlife, and aesthetic value on denuded sites.

Palatability and Nutritive Value

Arctic willow has been reported to contain 10 to 21% crude protein, 0.5 to 1.5% calcium, and 0.2 to 0.6% phosphorus. These values were considered adequate to provide nutritious forage for bighorn sheep (225). Also known to be an important food source for many arctic tundra wildlife species.

Seed or Planting Stock Availability

No commercial source of seed known.

Methods and Ease of Establishment

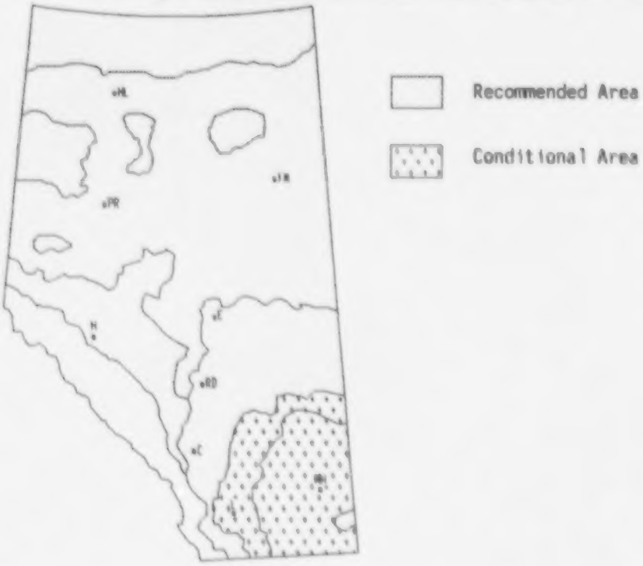
Seed. Sow seeds as soon as collected. Hardwood cuttings are also effective (21). Willows in general have been reported to be a readily obtainable woody plant material which roots rapidly and acts as a soil stabilizer. Tip cuttings (the upper 30 to 45 cm of willow shoots) can be collected in March or early April, tied in bundles with the base wrapped in wet paper towels and then stored at just above 0°C in plastic bags until planting time. These cuttings may then be planted to three-quarters their length at 45 cm intervals. The low growing types of willows (such as arctic willow) apparently provide good cover at relatively low cost (140).

Current Status for Reclamation

Arctic willow is found in alpine and subalpine environments in Alberta. It is usually confined to soils of low nutrient status. It is a slow growing pioneer that is palatable and is browsed by bighorn sheep. This species has potential use for revegetation of disturbed alpine areas in Alberta but research is needed into the best methods of propagation and early management.

Salix bebbiana

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance			X		
pH Acid			X		
Tolerance Base			X		
Winter Hardiness			X		
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance		X			
Moisture Preference	Moist to wet, tolerates flooding.				
Soil Preference	Sandy to gravel, well to imperfectly drained.				

Salix bebbiana Sarg.

SPECIES BIOLOGY

Taxonomy - Beaked Willow (78) Bebb Willow (443).

Includes var. perrostrata (Rydb.) Schneid.

Origin and Range

Native. Alaska east to Hudson Bay, Labrador and Newfoundland, and south to New Jersey, Nebraska, New Mexico and central California (443, 419). Also in eastern Asia (443).

Growth Habit

A tall coarse shrub, or small tree up to 10 m in height (443, 64).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Bebb willow establishes by seed, suckers, root shoots, and sprouting from branch segments (5, 347).

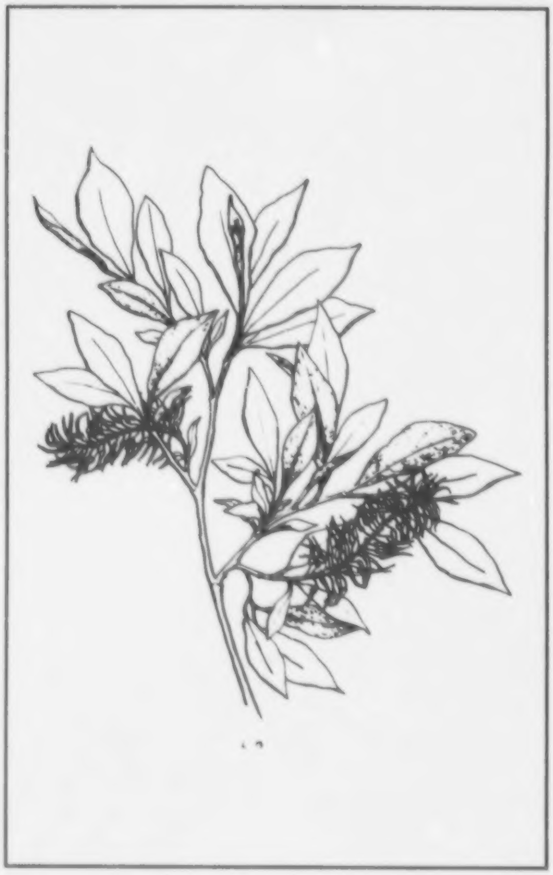
Ecological Setting

Bebb willow is very common throughout Alberta to the subalpine. It is common around sloughs in the prairies throughout the foothills and in upland forests of northern Alberta (78, 312, 64). In Alaska it is found in thickets adjacent to streams, swamps and lakes. Forms large spreading shrubs in meadows. Throughout most forest types as scattered individuals (443). In northern Alberta often representative of tall shrub borders of rivers (399). Common native associates: Salix lasiandra, Alnus tenuifolia, Cornus stolonifera, Rubus pubescens.

TOLERANCES

Soil Preferences

Bebb willow is usually found on moist, sandy or gravelly soils (399). It is adapted to a range of soil moisture conditions from well drained to poorly drained soils, which are usually waterlogged. It is found on a wide range of soil textures (5). This willow will withstand flooding during the growing season (5).



Nutrient Requirements

Expected to have low to moderate nutrient requirements.

Soil Reaction

Bebb willow will tolerate moderately alkaline soils but does poorly in extremely acidic or alkaline conditions (347). It is also tolerant of medium acid conditions (5). Bebb willow has been noted as a pioneer on flat, sandy barren areas near Sudbury, Ontario. These soils are very acid (pH 3.2 to 4.5).

Soil Salinity

Will probably tolerate moderately saline soils.

Drought

Does not tolerate drought well. Prefers sites with adequate moisture.

Heavy Metals and Hydrocarbons

Willows are reported to have a high tolerance of oil (282). Bebb willow has been observed growing on barren acid soils with elevated levels of Ni, Cn and Al, near Sudbury, Ontario (28).

Shade

Bebb willow has low shade tolerance (5, 356). It grows best in full sunlight (356).

Browsing - Regrows readily after browsing (347).

Susceptibility to Disease and Insect Damage

Willow sawfly may be a serious pest of willow cutting beds and rooted cuttings (102). Very heavy rodent damage on areas with heavy grass cover in northern Alberta (J. Sherstabetoff, pers.comm.).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Willows in general have shallow, dense root systems (205). Bebb willow has a moderate rate of height growth and a moderate cover rate (5). A relatively good soil stabilizer.

Adaptation to Disturbance

It is one of the most common species in willow stands succeeding fire on upland sites (443). Willows have been observed to invade mine spoil piles in southeastern B.C. (96) and Alberta (271, 357). Bebb willow has been observed invading barren acid soils near Sudbury, particularly after such soils received amendments of lime and phosphate (28, 479).

Competitive Ability

Moderately aggressive on suitable sites.

Commercial Value

Important source of "diamond willow" used for carving canes, lamp posts and furniture (443). Also important for wildlife browse (399) and for soil stabilization (205).

Palatability and Nutritive Value

Bebb willow is a major source of browse for moose and deer as well as rabbits and hares (347). Important browse for moose throughout Interior Alaska (443). Willows are reported to be heavily utilized by bighorn sheep, elk, mule deer, and moose on foothills range in Alberta (144).

Seed or Planting Stock Availability

Willow seed is not available from commercial sources because, in general, it is viable for only a few days (419). "Wilson" bebb willow was released in 1985 in Alaska for screening, windbreaks and living fences, as well as for reclamation (738).

Methods and Ease of Establishment

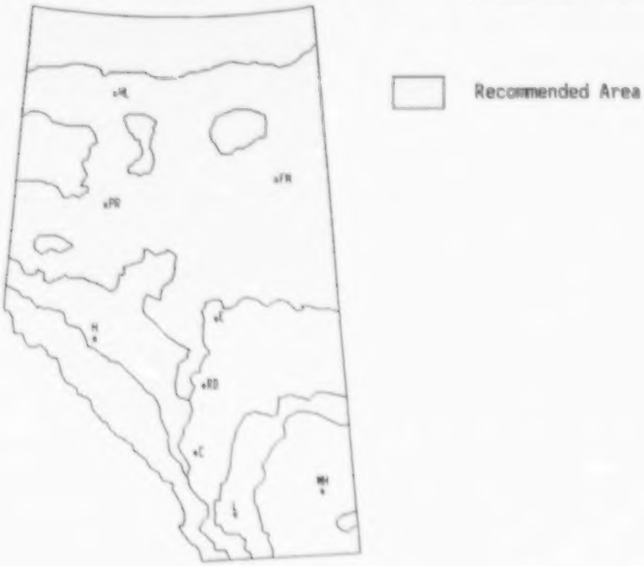
Seed, seedlings, transplants, and stem cuttings (53). Salix bebbiana is a spring dispersing willow. Seed is green when preripe, and yellowish when ripe (419). In general, willow seed germinates in 12 to 24 hours (419). The maximum period of storage is from 4 to 6 weeks, but viability is markedly reduced after 10 days for seed stored at room temperature (419). However S. glauca and S. alaxensis were successfully stored for 14 to 16 months in polyethylene bags at -10°C with no loss in seed viability (492). Seed must be sown immediately after collection. Seedbeds must be moist for good seedling establishment (419). Recommended that plants be spaced at 1.5 m intervals (5). Cuttings of Salix bebbiana did not root as readily as S. alaxensis. Rooting was more rapid in stems collected during the spring than in those collected in the fall (116). At the Indian Head Nursery in Saskatchewan, rooted willow cuttings are produced from 15 cm hardwood cuttings. These are harvested in early fall, stored over winter at 1°C and planted in the spring. The cuttings are planted out the following year as one year old (1-0) rooted cuttings (102). Rooting capacity of hardwood willow cuttings was greatest (95 to 97%) for those cuttings immediately placed in cold storage after collection. If the hardwood shoots were exposed to indoor temperatures for even a short period after collection (6 days), rooting was significantly reduced (103).

Current Status for Reclamation

Salix bebbiana and S. interior hardwood stem cuttings (1-0) had a survival of from 30 to 70% on mine overburden in northern Alberta. Mortality was largely attributed to rodent damage. S. bebbiana had poor overwintering ability on oil sands tailings (J. Sherstabetoff, pers.comm.). Fourth year survival of Bebb willow plantings on amended tailings sand averaged 63%. Competition from ground cover negatively affected survival and growth. Growth averaged 15 cm/year, similar to "Northwest" poplar, silverberry and green alder (641). Bebb willow is recommended for revegetation planting in the southwest area of Alaska (5).

Salix glauca

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA		SUITABILITY RATING			
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance				X	
pH Tolerance Acid			X		
pH Tolerance Base					
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance		X			
Moisture Preference	Moist to wet, waterlogged.				
Soil Preference	Wide range of textures, well to poorly drained.				

Salix glauca L.

SPECIES BIOLOGY

Taxonomy - Grayleaf Willow (443).

Var. *villosa* (Hook.) Anderss.

Origin and Range

Native. Alaska east to Labrador and Newfoundland, south to southern British Columbia; in the Rocky Mountains to northern New Mexico. Also in northern Europe and Asia (443).

Growth Habit

An erect shrub 0.5 to 2 m tall (312). It may be repressed and spreading in exposed sites and in favourable sites can become a small tree to 6 m in height and 12.5 cm in diameter (443).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Grayleaf willow spreads by seed. The stump will resprout if cut or destroyed by fire (323). In severe sites it may spread by means of rooting of long horizontal stems (369).

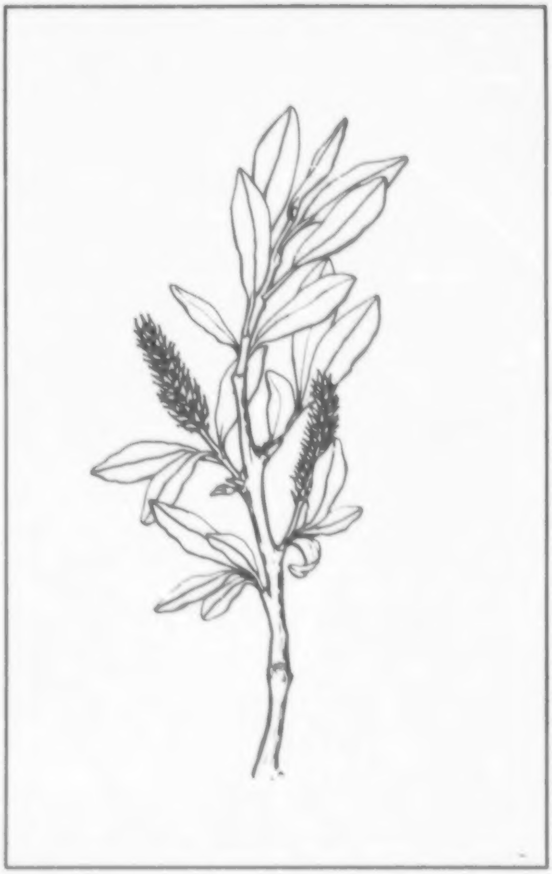
Ecological Setting

A widely variable species. It occurs over a wide range of habitats. In the arctic and western Alaska it grows on river cutbanks and floodplains and in protected sites on tundra (443). It occurs in most forest types in the boreal forest. In B.C. it is common in open or semi-open well drained sites east of the coastal mountains, and at or above timberline it forms extensive thickets (particularly in the north) (64). In northern and western Alberta, it is found in meadows, bogs, along streams and on Rocky Mountain slopes (690).

TOLERANCES

Soil Preferences

Grayleaf willow is found on a range of soil moisture conditions from well drained to poorly drained soils that are usually waterlogged (5). It is adapted to a wide range of soil texture conditions (144). In arctic Norway, it is found on shallow, waterlogged organic soils (369).



Nutrient Requirements

Moderate nutrient requirements.

Soil Reaction

Grayleaf willow has moderate tolerance to acid soil conditions (5).

Soil Salinity

Not generally found on saline sites.

Drought

Will not grow on sites where moisture stress is high.

Heavy Metals and Hydrocarbons

In a study of the heavy metal content of tundra plant species, willows were found to accumulate Zn, Cd, U, Pb, Co and Cu (332). Willows, in general, have been reported to have a high tolerance of oil (282).

Shade

Grayleaf willow has low shade tolerance (5).

Browsing

Tolerant of very heavy browsing. Will resprout from root crown if cut.

Susceptibility to Disease and Insect Damage

No specific susceptibility noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Grayleaf willow has a moderate cover rate (5), and can be expected to provide moderate soil stabilizing abilities.

Adaptation to Disturbance

Grayleaf willow is a common pioneer after fire and occurs along roadsides and rivers. It also invades glacial outwash, mine tailings and abandoned fields in interior Alaska (443). Grayleaf willow was reported to invade disturbed sites on the Tuktoyaktuk Peninsula, N.W.T. and mud slumps in the Mackenzie River Delta (332).

Competitive Ability

S glauca is fairly aggressive on preferred sites such as burned-over areas in northwestern Alberta.

Commercial Value

An important wildlife browse species (144, 443). Soil stabilizer.

Palatability and Nutritive Value

Important browse source for moose (443). Willows generally are preferred food of bighorn sheep, elk and mule deer on foothills range in Alberta (144).

Seed or Planting Stock Availability

No source of commercial seed or planting stock is known; however, operators are relatively successful in propagating planting materials.

Methods and Ease of Establishment

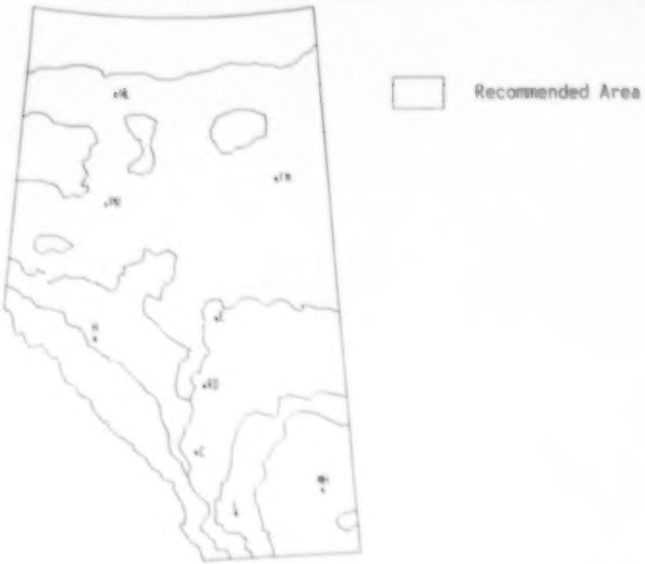
Seed, seedling and transplant, stem cuttings and root cuttings (5) are all acceptable methods of establishment. Maximum spacing recommended is 3 m by 3 m (5). Hardwood cuttings generally fare better than softwood cuttings (332). Grayleaf willow cuttings did not root as readily under laboratory conditions as *S. alaxensis* or *S. rovae-angliae* (115). Grayleaf willow disperses seed in the autumn. Seed has been successfully stored in polyethylene bags at -10°C for 14 to 16 months (492). Unlike most willows, grayleaf willow seed required stratification before germination can occur (493). Wide variations exist within the species, however. Some varieties may set seed in spring, while others ripen as late as October (495).

Current Status for Reclamation

Stem cuttings have been successfully used for revegetating unstable sand dunes in northern Alberta (258). Performance testing has indicated that while survival may be high, vigour tended to be low and dieback rate high (645, 706). Grayleaf willow did not survive in tests in the alpine region at Tent Mountain, Alberta (707). Recommended for revegetation of arctic and alpine areas in Alaska (5). Early (1931) plantings of grayleaf willow wildings on the Wasatch Plateau, Utah (subalpine) were reported as failures (337). In New Zealand, willow cultivars are widely used for erosion control, and a mechanical technique for deep planting of willow poles on deep unstable mountains scree slopes has been developed (203).

Salix scouleriana

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X	X	
Salt Tolerance			X		
pH Tolerance Acid		X			
pH Tolerance Base					
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X			
Browse Tolerance	X				
Moisture Preference	Moist to wet, well to poorly drained waterlogged soils.				
Soil Preference	Wide textured range, also peat soils.				

Salix scouleriana Barr. ex Hook.

SPECIES BIOLOGY

Taxonomy

Scouler Willow (205); Mountain Willow (608).

Includes var. coetanea Ball.

Origin and Range

Native. Alaska east to Saskatchewan and south to New Mexico and California (443). It is the most common willow of southeastern and south central Alaska (428). Throughout B.C. but less common inland compared to other willows. The variety coetanea Ball occurs mainly east of the coastal mountains (64). Western and northern Alberta and Cypress Hills (690).

Growth Habit

In Alberta, a shrub or small tree 2 to 8 m high (690). In Alaska, it may reach heights of 15 to 18 m with a trunk diameter of 40 to 50 cm (443). Fast growing shrub or small tree (608).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

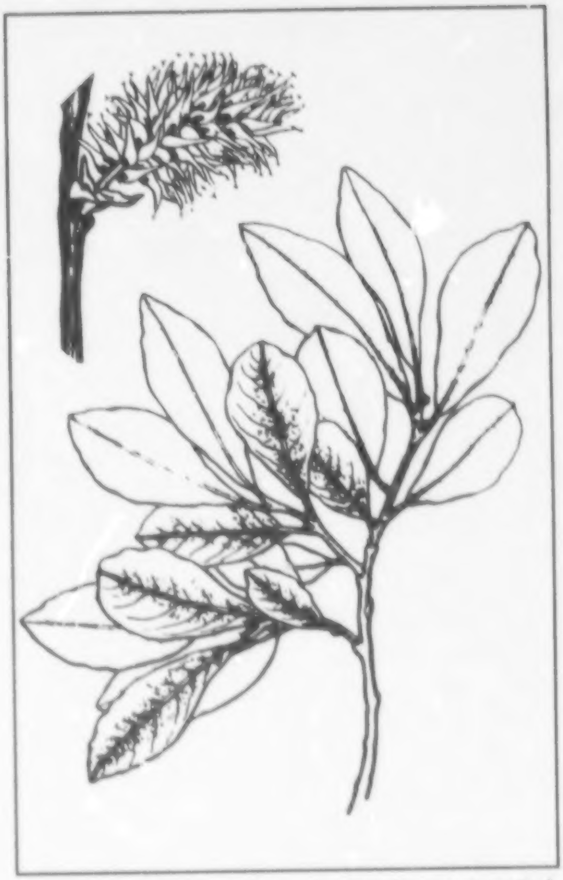
Seed; resprouts from cut trunk; branch segments (5). Rated moderate for natural vegetative reproduction (338).

Ecological Setting

Occurs over a wide range of habitats. In Alaska, Scouler willow is a common upland species where it has become widespread after fires. It is common in areas disturbed by logging and also along streams and roadsides (443). In Alberta, it is most common in the foothills and in northern Alberta on hillsides and along streams (312).

TOLERANCES

Soil Preferences



Scouler willow is adapted to a range of soil moisture conditions. It is found on well drained through to very poorly drained soils that are waterlogged (5). In Alaska, it is not very well adapted to excessively drained soils that are susceptible to drought. It has been reported, however, that Scouler willow is well adapted to dry mountain slopes in Utah and Idaho (302). Scouler willow is found on a range of mineral soil textures and also occurs on peaty soils (5, 174, 61).

Nutrient Requirements

Moderate nutrient requirements. Seems to do best on burned over sites where there is a flush of nutrients.

Soil Reaction

Scouler willow has a high tolerance of acid soil conditions (5).

Soil Salinity

Will not tolerate excessively saline soils.

Drought

Does not generally tolerate drought in northern latitudes (5), but is found on dry sites in the southern part of its range (302). Has invaded dry sites near Cadomin, Alberta (357).

Heavy Metals and Hydrocarbons

Willows, in general, have been reported to have a high tolerance of oil (282). No other tolerances are known.

Shade

Scouler willow has low tolerance of shade (5).

Browsing

Salix scouleriana produces the greatest amount of browse on branches which are browsed the previous winter. In one study area, an average unbrowsed branch produced 2.4 g of new growth, whereas a browsed branch produced 4.0 g of new growth in a given year (481).

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

It has a relatively rapid height growth rate and a moderate cover rate (5). Scouler willow has been rated as good for ability to stabilize soil (337, 338). It has a moderate rate of spread by seed and vegetative means (337).

Adaptation to Disturbance

Scouler willow rapidly invades burned areas, often forming dense thickets (443). It also invades other disturbed sites such as logging areas and roadsides (443). It has been reported as a pioneer on coal mine spoil piles near Cadomin, Alberta. The Cadomin site, at 1 675 m ASL, has severe climatic limitations (drought, wind) (357). Pioneer on gravel beds subject to moisture stress in Washington, U.S.A. (157).

Competitive Ability

Very aggressive on preferred sites often shading out other species, but will act as a "nurse" species for conifers which are shade tolerant (eg. white spruce).

Commercial Value

Source of "diamond willow" for carving, furniture, etc. (443); watershed protection (302); wildlife food and cover (144, 446).

Palatability and Nutritive Value

Scouler willow is an important source of browse for moose. In southcentral Alaska trees are commonly barked by moose (443). Salix spp. are preferred foods of bighorn sheep, elk, and mule deer on foothills range in Alberta (144). Provides good cover for mule deer, game birds and small mammals, good forage for mule deer and small mammals but only fair forage for game birds (446). Important winter browse for moose and deer (608).

Seed or Planting Stock Availability

No commercial source of seed or planting stock is known, but operators have generally good success at propagating for rehabilitation purposes.

Methods and Ease of Establishment

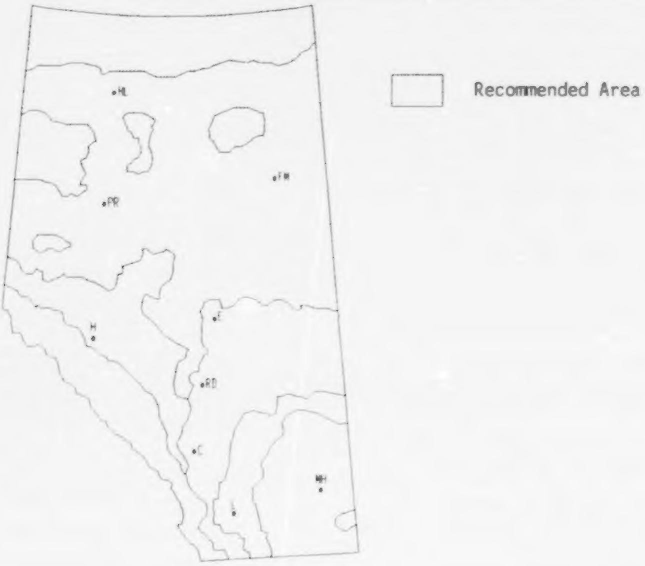
One of the earliest flowering willows. In Alaska, it flowers in May, seeds disperse in June and catkins are shed by July (443). In general, seed must be sown immediately after collection. Willow seed germinates in 12 to 24 hours. Seedbed must be moist for good seedling establishment (443). Hardwood cuttings are generally better than softwood cuttings (322, 380). Seedlings, transplants and stem cuttings planted at a maximum spacing of 1.5 m by 1.5 m have been recommended (5). Scouler willow can be readily planted as stem and root cuttings, or rooted in the greenhouse and then planted out (302, 303). It has been rated as good for establishment by transplants (337). Reported to have low establishment requirements.

Current Status for Reclamation

Scouler willow has been used by state and federal agencies for watershed plantings (streambank stabilization) in Utah (302). It is also considered useful for providing an environment in which other species can become established (302). Early (1931) plantings of Scouler willow wildlings on the Wasatch Plateau, Utah (subalpine) were reported as failures (377). Nonetheless it has been suggested as a suitable shrub for revegetation in the subalpine in Utah (337). Scouler willow has been recommended as a plant species suitable for revegetation of disturbed lands in the juniper-pinon woodland zone in northwestern Colorado. It is best suited to a wet habitat with an optimum slope of 0 to 8% (362). In New Zealand willow cultivars are widely used for erosion control, and a mechanical technique for deep plantings of willow (Salix spp.) poles (cuttings) on deep unstable mountain screes has been developed (203).

Shepherdia canadensis

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid			X		
pH Tolerance Base			X		
Winter Hardiness		X	X		
Erosion Control			X		
Persistence		X			
Palatability				X	
Browse Tolerance		X	X		
Moisture Preference	Moist to dry.				
Soil Preference	Silt loam to sandy loam, well to moderately well drained.				

Shepherdia canadensis (L.) Nutt.

SPECIES BIOLOGY

Taxonomy - Canadian Buffalo-berry.

Origin and Range

Native. Alaska and Yukon Territory to James Bay and Newfoundland, south in the mountains to Maine, New York, Michigan, New Mexico, and Oregon (443).

Growth Habit

Canadian buffalo-berry is a deciduous thornless shrub; 0.6 to 2.0 m tall (443, 690).

Nitrogen Fixing

Fixes nitrogen; in solution culture nodulation occurred at pH 6 and 7 but not at pH 5 (164); nodulated plants have been observed in the subalpine (Colorado) (44). Associated with the N_2-fixing actinomycete Frankia and vesicular-arbuscular mycorrhizae (728). Shoot weights of 12 week old inoculated buffalo-berry seedlings were 3 times greater than uninoculated seedlings and root weights were 4 times greater (Visser and Danielson 88).

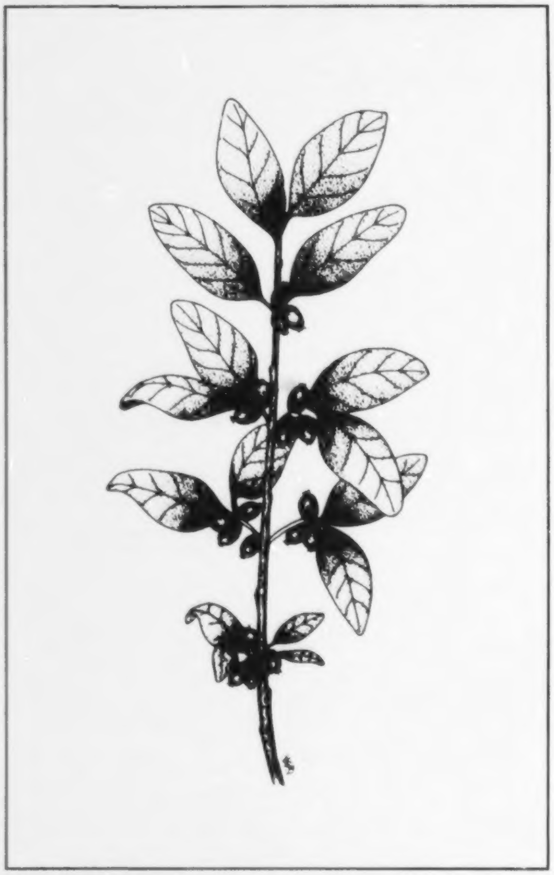
Longevity - Long-lived perennial.

Self Propagation

Seed and suckers (J. Sherstabetoff, pers.comm.), although suckers are very short and propagation by this means is questionable (D. Walker, pers.comm.).

Ecological Setting

Throughout forested region of Alberta. Also found in the Cypress Hills and along the South Saskatchewan River banks. Open forests or dry uplands, aspen forests or old burns; river banks and gravel bars (443, 78); occurs over a wide range in elevation up to 2 300 m to 3 500 m ASL in the Rocky Mountains in Colorado (356). Occurs to, or slightly above, timberline (501). Common native associates (mixed wood): Populus tremuloides, Rosa acicularis, Viburnum edule, Picea glauca; also common in dry, open lodgepole pine forests (365).



TOLERANCES

Soil Preferences

Found on coarse textured (silt loam to sandy loam) and well to moderately well drained soils (5). It is apparently well suited to planting on dry, rocky banks where few other shrubs can survive (419).

Nutrient Requirements

Buffalo-berry is capable of growing at low nitrogen levels characteristic of glacial outwash (332). It has been observed growing on poor sites such as erosion slopes in Alberta (306). Twenty week old seedlings were larger when fertilized in the greenhouse, but had considerably fewer nodules (728) which may have an effect on planting stock quality.

Soil Reaction

Buffalo-berry can tolerate moderately alkaline (pH 8.0 to 8.4) to moderately acidic soils (332).

Drought - Moderate drought tolerance (5, 419).

Heavy Metals and Hydrocarbons

No specific tolerances noted.

Shade

Moderately tolerant. Grows in partial shade (356).

Browsing

Generally not browsed, but will regrow successfully from heavy pruning.

Susceptibility to Disease and Insect Damage

Buffalo-berry is susceptible to leaf spot, leaf rust and powdery mildew, among others (198).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The species often forms dense thickets (443). The related thorny buffalo-berry (S. argentea (Pursh.) Nutt.) has been used for revegetation of roadcuts and other disturbed or eroded areas in Utah (336).

Adaptation to Disturbance

Buffalo-berry is common on disturbed sites throughout the eastern slopes of the Rocky Mountains in Alberta (365). It is often a pioneer on glacial outwash (332).

Competitive Ability

Moderately aggressive due to suckering ability.

Commercial Value

The berries are eaten by grouse and bears; it is also important as a ornamental (443) and is used for erosion control. It is a nitrogen fixer (120).

Palatability and Nutritive Value

Buffalo-berry has low palatability (427) but is reported to be lightly browsed by deer and elk (393). Berries provide forage for bears.

Seed or Planting Stock Availability

Limited commercial supplies of seed exist, but costs are high, and adapted ecotypes may not be available (349). Seed yield averages 26 kg per 100 kg of fruit and 90 400 seeds comprise a kilogram.

Methods and Ease of Establishment

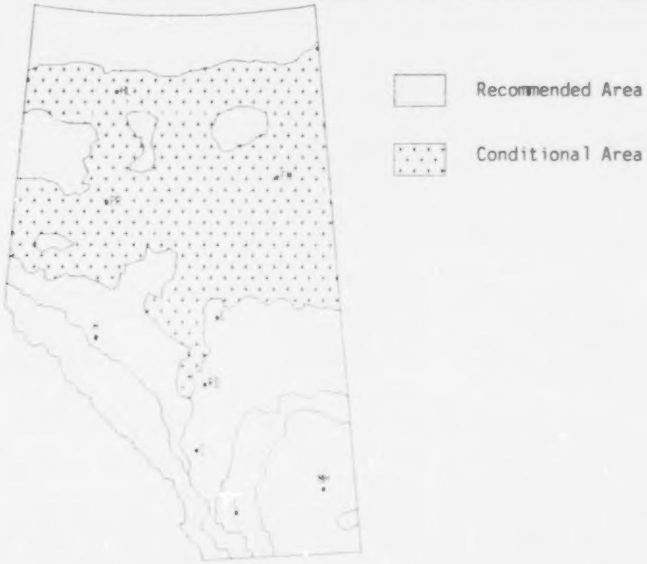
Seed should be collected from June to August. Chemical harvesting of seed produced good results (434). Seedcoat dormancy occurs and can be treated with H_2SO_4 for 10 to 30 minutes. Germination ranges from 14 to 19% (150). Germination rates of 40 to 75% have been reported for 6 seed collections in northern Alberta (J. Sherstabetoff, pers.comm.). Cold stratification for 60 days followed by seeding in the greenhouse has been moderately successful (D. Klym, pers.comm); or sow in the fall at 0.6 cm depth at a rate of 350 seeds/m^2 (119). Most easily propagated from seed (149). Can also be done with suckers (21) or root cuttings (120). Buffalo-berry is well suited to transplanting in containers; root cuttings of various types provide low success (0 to 1%) (268, 150).

Current Status for Reclamation

Excellent fourth year survival (85%) was found on amended tailings sands near Fort McMurray. Top growth averaged 5 cm per year in the first four years (641). Inoculated seedlings outplanted on amended tailings sand had much lower survival in the first year; however, the survivors were much larger than their uninoculated counterparts, even after two years (728). Seeding was moderately successful on amended tailings sand in northern Alberta (A. Fedkenheuer, pers.comm.). Buffalo-berry has been recommended for planting on mine spoils on dry sites in British Columbia. Seed and root cuttings were the methods of establishment (120). Second year survival of bareroot stock in the subalpine (Coleman, Alberta) averaged 52% (708). Buffalo-berry is often found on disturbance sites throughout Alberta to the subalpine. Recommended for revegetation on moist to dry sites in Alaska. Seed, seedlings, and transplants were suggested means of establishment (5). It is cold-hardy and tolerant of drought. Its abilities to form thickets and fix atmospheric nitrogen make this species a prime candidate for erosion control on dry sites in the western and northern parts of the province. Further research is needed into methods of establishment, since germination rates are low and results from cuttings have been variable.

Spiraea betulifolia

SPECIES SUITABILITY MAP AND SUMMARY TABLE



Commercially Available: Yes___ No X

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance				X	
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base				X	
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability				X	
Browse Tolerance			X		
Moisture Preference	Moist.				
Soil Preference	Loamy soils, well to moderately well drained.				

Spiraea betulifolia Pallas

SPECIES BIOLOGY

Taxonomy - White Meadowsweet; White Spirea.

Also S. lucida Dougl.

Origin and Range

Native. Common species of the Rocky Mountains and also eastward in the foothills and montane zone in Alberta. Common in the Cypress Hills (78, 312). British Columbia east to Saskatchewan, South Dakota and south to Wyoming and northern Oregon.

Growth Habit

White meadowsweet is a low deciduous shrub 0.3 to 1.0 m high. The stems and branches are erect, often dying down annually to the base. It has creeping rootstocks (78, 690).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation

Seed and spreads vigorously by rhizomes (395).

Ecological Setting

White meadowsweet is common in open aspen groves and lodgepole pine forests of the eastern slopes of the Rocky Mountains in Alberta. It is also found on open slopes (690). It grows in a wide range of habitats from sea-level to the subalpine but it does best on recently disturbed sites in moist forests at moderate elevations (419).

TOLERANCES

Soil Preferences

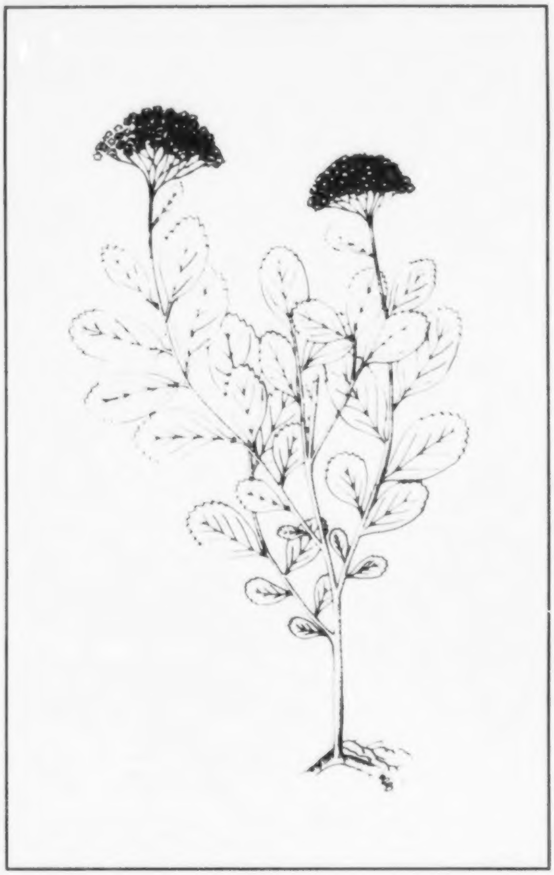
Observed to prefer moist loamy soils which are well to moderately well drained.

Nutrient Requirements

Grows on sites with low nutrient status.

Soil Reaction

Will grow on soils which are mildly acidic to mildly alkaline.



Soil Salinity - Found on moderately saline sites.

Drought

Found on sites subject to some moisture stress.

Heavy Metals and Hydrocarbons

No specific tolerances noted, but observed to grow on fuel soaked soils.

Shade

A common inhabitant of the forest understory, where other species are shaded out. Does best on open to semi-shady sites.

Browsing

Will resprout after cutting or browsing.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

The extensive rhizome system and the ability to colonize disturbed sites suggest that this species is good for soil building and erosion control.

Adaptation to Disturbance

White meadowsweet has been observed as a pioneer on drill pads in the southeast coal block in British Columbia (70). It is found on disturbed sites throughout the eastern slopes of the Rocky Mountains in Alberta particularly in the southern parts of the province wherever a seed source is nearby (365). White meadowsweet has been observed as a pioneer on disturbed mine sites in British Columbia particularly in those sites close to lodgepole pine of the Interior Douglas Fir Zone (384).

Competitive Ability

Observed to be aggressive on favoured sites.

Commercial Value

Watershed protection (302); ornamental (419, 608).

Palatability and Nutritive Value

White meadowsweet was reported to be lightly browsed in an area frequented by deer and elk in southeastern B.C. (393).

Seed or Planting Stock Availability

No commercial source of seed is known. Available from some growers as container stock (608).

Methods and Ease of Establishment

The fruit is light brown when ripe. White meadowsweet seeds do not have a seedcoat or an embryo dormancy, and seed therefore does not require stratification. Seed germinates at low temperatures (0 to 2°C). It should be sown in late fall or early spring to take best advantage of favourable moisture conditions at spring melt. Seed collected in British Columbia was reported to have a germination capacity of 68%. Root cuttings are also a successful method of establishment (119, 419).

Current Status for Reclamation

Spiraea spp. are used for reclamation in Denmark. White meadowsweet has been planted in Idaho for watershed protection (302). It has been rated as potentially useful for watershed rehabilitation particularly, because of its strongly rhizomatous nature (419).

Symphoricarpos albus

SPECIES SUITABILITY MAP AND SUMMARY TABLE

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Recommended Area

Commercially Available: Yes X No___

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid				X	
Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Moist.				
Soil Preference	Medium textured to rocky.				

Symphoricarpos albus (L.) Blake

SPECIES BIOLOGY

Taxonomy - Snowberry; Common Snowberry.

Origin and Range

Native. Southeast Alaska, Queen Charlotte Islands, and British Columbia across Canada to Quebec, south to Virginia, Michigan, Nebraska, Colorado and California (443).

Growth Habit

Snowberry is an erect, deciduous shrub from 0.5 m to 1 m in height, often dwarf with many slender branches (78, 690).

Nitrogen Fixing - None

Longevity - Long-lived perennial.

Self Propagation - Seed, spreads by suckers.

Ecological Setting

S. albus is found in woodlands and open areas throughout the prairies, in the Cypress Hills, and in the foothills and mountain zone of the eastern slopes. It is often associated with upland aspen-white spruce forests in the north and in southern areas with open mountain aspen groves and lodgepole pine forests (78, 690, 365, 399).

TOLERANCES

Soil Preferences

Snowberry is found on coarse textured and rocky soils (78). In northwestern Colorado, snowberry (Symphoricarpos sp.) occurs on moister areas and at elevations above 2 200 m ASL, but is absent on dry, south and west-facing slopes (307).

Nutrient Requirements

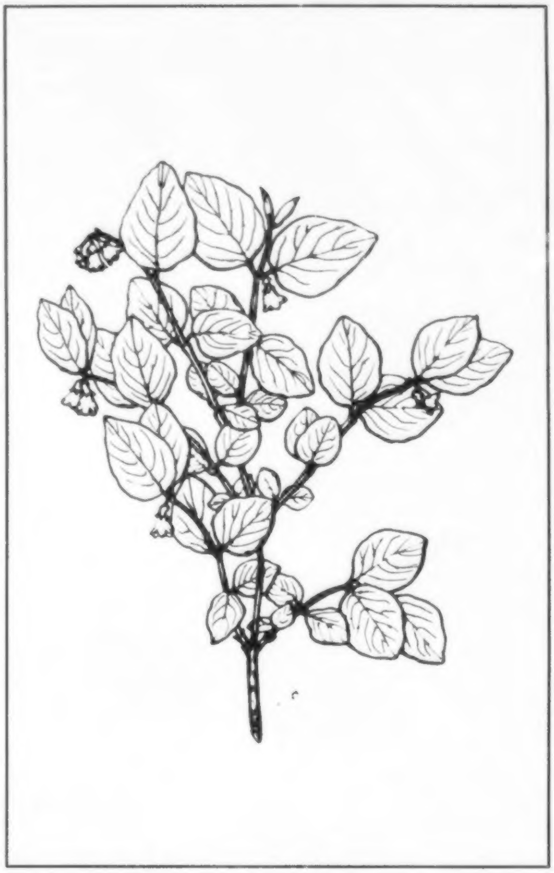
Will tolerate low nutrient sites.

Soil Reaction

Will tolerate mildly acidic to moderately alkaline soils.

Soil Salinity

Grows on mildly saline sites. Not as tolerant as S. occidentalis.



Drought - Moderately drought tolerant.

Heavy Metals and Hydrocarbons

No specific tolerances noted, but commonly found on oil spill sites.

Shade

Prefers open sites but will grow in partial shade.

Browsing - Will resprout after cutting or grazing.

Susceptibility to Disease and Insect Damage

No specific pests noted.

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Snowberry is a thicket forming shrub (419, 120), and, as such, affords some soil protection.

Adaptation to Disturbance

Snowberry was a principal native shrub to invade a burned, forested area in Oregon. After 2 years, it comprised 15% of the ground cover (15). Snowberry was found on disturbed sites throughout the eastern slopes of the Rocky Mountains, wherever a seed source was nearby; it was more prevalent on disturbed sites in the south than in the north, and was rarely found on disturbed sites in the subalpine (365).

Competitive Ability

On burned areas in Oregon, development of snowberry was much greater on an unseeded area compared to an area seeded with various grass species. Snowberry establishment was suppressed by competition from the grasses (15).

Commercial Value

Snowberry has been used to provide cover and forage for wildlife and as an ornamental (419); erosion control (120).

Palatability and Nutritive Value

Snowberry is an important browse species for deer and elk (15). Moderate use has been reported for Rocky Mountain mule deer (245). Fruit is used by birds in the winter.

Seed or Planting Stock Availability

Native seed is available from commercial American sources, but costs are high. The number of seeds per kg of fruit averages about 119 000; approximately 167 000 seeds/kg (639).

Methods and Ease of Establishment

Propagation from seed is difficult (120). Ripe fruit can be collected in the fall by knocking or stripping the fruit clusters onto canvas. The fruit is white when ripe. Seed can be extracted by macerating the fruit with water and screening off the pulp and the empty seeds. Dried seeds can be stored for several years at either room temperature or 5°C. Seeds have a hard seedcoat and embryo dormancy. Warm stratification at 20°C for 4 to 6 months has been used to overcome seedcoat dormancy. Sulphuric acid scarification produced variable results. Cold stratify at 5°C for 3 to 4 months. Sow seeds 0.6 cm deep at a rate of 350 seeds per m^2. Seeds can be sown in the spring for germination the following spring. Other methods of establishment are division, hardwood and softwood cuttings and suckers (419, 21, 119).

Current Status for Reclamation

First year survival of snowberry on amended tailings sand in northern Alberta has been reported to be very good (75%) (378). Snowberry is often found on dry, disturbed sites to the upper montane in Alberta. It is a thicket-forming shrub with potential for use in erosion control. It has been recommended for erosion control throughout British Columbia (120). Snowberry has been used for reclamation of coal mine spoil in British Columbia (497). It is difficult to establish from seed and can not compete with grasses. It is a valuable source of wildlife browse.

Symphoricarpos occidentalis

SPECIES SUITABILITY MAP AND SUMMARY TABLE

Recommended Area

Commercially Available: Yes___ No_X_

RECLAMATION SUITABILITY CRITERIA	SUITABILITY RATING				
	Very High	High	Medium	Low	None
Drought Tolerance			X		
Salt Tolerance			X		
pH Tolerance Acid				X	
pH Tolerance Base			X		
Winter Hardiness		X			
Erosion Control			X		
Persistence		X			
Palatability		X	X		
Browse Tolerance			X		
Moisture Preference	Dry to moist.				
Soil Preference	Silt clay loams to sandy loams, moderately well to imperfectly drained.				

Symphoricarpos occidentalis Hook.

SPECIES BIOLOGY

Taxonomy

Buckbrush; Badger Brush; Wolfberry; Western Snowberry (608).

Origin and Range

Native. British Columbia east to Michigan, south to Illinois and New Mexico (419).

Growth Habit

Buckbrush is a spreading, robust shrub up to 1 m in height; deciduous (78, 690); colonies may grow from 1 m to 200 m in diameter (602).

Nitrogen Fixing - None

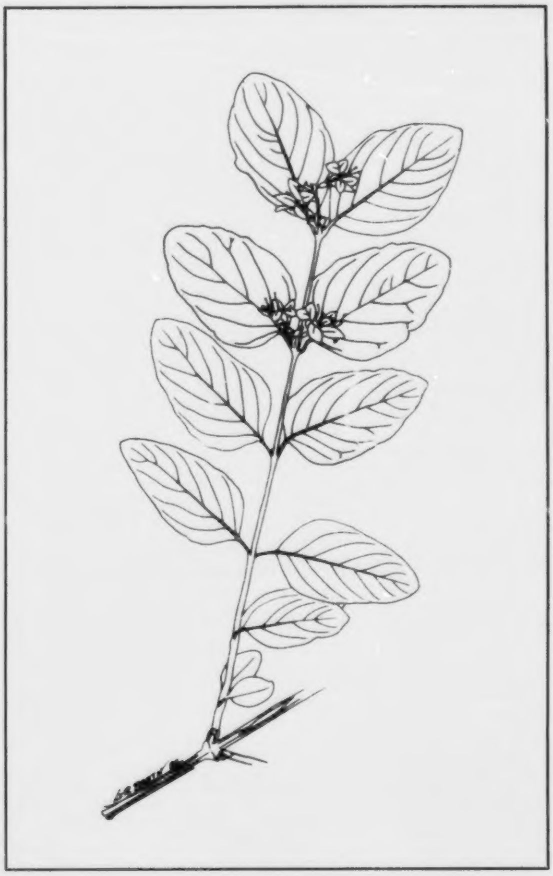
Longevity - Long-lived perennial.

Self Propagation

Reseeds itself and spreads by suckers (690).

Ecological Setting

Buckbrush is very common throughout the prairies where stands are often dense. It is common in ravines, coulees and throughout aspen groves (78, 690).



TOLERANCES

Soil Preferences

Found on a range of soils from silty clay loams to sandy loams with moderate to poor drainage.

Nutrient Requirements

Grows on low nutrient sites.

Soil Reaction

Will tolerate mildly acidic to moderately alkaline sites.

Soil Salinity

Buckbrush is moderately tolerant of saline soil. It is found as a component of pioneering communities on saline mine spoils material near Estevan, Saskatchewan (230).

Drought - Moderately drought tolerant.

Heavy Metals and Hydrocarbons

No specific references noted, but thought to be moderately tolerant of hydrocarbons.

Shade

Will grow in partial shade but prefers open sites.

Browsing - Will resprout after cutting.

Susceptibility to Disease and Insect Damage

Buckbrush is susceptible to herbicide damage (197).

RECLAMATION CONSIDERATIONS

Soil Building and Erosion Control Capability

Buckbrush is a thicket-forming shrub (419), and can be expected to offer some protection against erosion.

Adaptation to Disturbance

Invader of disturbed sites in areas of adaptation.

Competitive Ability

Buckbrush is strongly competitive with grasses; in a field experiment near Edmonton it increased as rapidly in plots seeded with grass as in unseeded plots (24). Considered to be a "problem" species on rangeland in Alberta; a mow and spray, or burn and spray control program is recommended (602).

Commercial Value

Buckbrush has been used for erosion control and wildlife habitat plantings (419). The domestic goat (Capra capra) selects against buckbrush (D. Wooley, pers.comm.).

Palatability and Nutritive Value

Buckbrush is not a preferred browse species for cattle (197), though sheep and goats will use it to a greater extent (602). It is reported to be moderately to heavily consumed by Rocky Mountain mule deer (245).

Seed or Planting Stock Availability

Container stock is available from some growers (608). The number of seeds per kg of fruit averages 160 000.

Methods and Ease of Establishment

Ripe fruit can be collected in the fall by knocking or stripping the fruit clusters onto canvas. The fruit is white when ripe. Seed can be extracted by macerating the fruit in water and screening off the pulp and empty seeds. Dried seeds can be stored for several years at room temperature or at 5°C. Seeds have a hard seedcoat and embryo dormancy. Warm stratification at 30°C for 3 to 4 months has been used for fall sowing of buckbrush. For spring sowing, the warm stratification should be followed by cold stratification at 5°C for 6 months. Sow seeds 0.6 cm deep at 350/m^2. Other methods of establishment are division, hardwood and softwood cuttings and suckers (24, 169, 419).

Current Status for Reclamation

Buckbrush is a robust shrub that often spreads by suckers forming dense thickets on the open prairie. It has been used for erosion control. It is moderately tolerant of drought and saline soil conditions and can compete with seeded grasses. It may be one of the better shrubs for planting on sodic clays; it is a common invader on old sodic mine spoils in the Tofield-Canmore-Round Hill area (T. Laidlaw, pers.comm.).

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3. D. Klym, Suncor Inc. February, 1980.
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12. P.F. Ziemkiewicz, Advisory Services and Research Division, Alberta Department of Energy and Natural Resources. July, 1980.

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6. Mr. J. Hayes
Interprovincial Pipe Line Limited
Edmonton, Alberta
October, 1989.

7. Dr. J. Davidson
Beaverlodge Research Station
Agriculture Canada
Beaverlodge, Alberta
November, 1989.

8. Ms. G. Harrison
Western Region Office
Canadian Parks Service
Calgary, Alberta
November, 1989.

9. Dr. W. Willms
Agriculture Canada Research Station
Lethbridge, Alberta
October, 1989.

10. Mr. R. Hermesh
Plant Materials Division
Alberta Environmental Centre
Vegreville, Alberta
November, 1989.

11. Ms. A. Smreciu
Plant Materials Division
Alberta Environmental Centre
Vegreville, Alberta
November, 1989.

12. Mr. B. Adams
Alberta Forestry, Lands and
Wildlife
Public Lands Division
Lethbridge, Alberta
January, 1990.

APPENDIX

Appendix

The following is a summary of additional species of grasses, forbs, shrubs and trees that have or may have potential for reclamation in Alberta.

Species	Common Name	Natural Distribution	Commercially Available	Reclamation Information	Comments
HERBS					
Typha latifolia	Common cattail	Widespread in wetlands of grassland, parkland and boreal forest	No	Yes	Fast growing, wildlife habitat, sewage treatment
Carex aquatilis	Sedge	Widespread in wetlands throughout Alberta	No	None	Fast growing, wildlife habitat
GRASSES					
Bouteloua gracilis	Blue grama	Dry grasslands	Yes	Yes	Drought and grazing tolerant
Stipa comata	Spear grass	Grasslands	Yes	Yes	Dominant prairie grass, drought tolerant
Festuca scabrella	Rough fescue	Aspen parkland	Yes	Yes	Dominant grass of parkland, and Cypress Hills, palatable
Festuca saximontana	Fescue	Foothills and aspen parkland	Yes	None	Winter hardy and palatable
Agropyron latiglume	Broad glumed wheatgrass	Subalpine and alpine	No	None	Cold tolerant, erosion control
SHRUBS					
Ribes spp.	Currents and gooseberries	Widespread throughout Alberta	Yes (several varieties)	Yes	Hardy, shade tolerant, wildlife habitat, ornamental value
Vaccinium spp.	Blueberries	Widespread in boreal, forest, foothills and subalpine	Yes	Yes	Hardy, shade tolerant, wildlife habitat, ornamental value
Salix exigua	Sandbar willow	Riparian wetlands	No	Yes	Fast growing, erosion control, flood tolerant, sandy soil
Caragana arborescens	Common caragana	Introduced hedges and windbreaks in grasslands and parkland	Yes	Yes	Drought tolerant, hardy, aggressive, wildlife habitat
Betula glandulosa and pumila	Dwarf birch and bog birch	Boreal forest and foothills wetlands	No	No	Flood tolerant, hardy, wildlife habitat
Corylus cornuta	Beaked hazelnut	Boreal forest	Yes	Yes	Hardy, wildlife habitat, ornamental value
Viburnum edule	Low-bush cranberry	Widespread throughout forest areas	Yes	Yes	Shade and chinook tolerant, wildlife habitat, ornamental value
Ledum groenlandicum	Labrador tea	Widespread throughout forest areas	No	No	Hardy, shade and acid tolerant, erosion control

Appendix (Continued)

Species	Common Name	Natural Distribution	Commercially Available	Reclamation Information	Comments
TREES					
Picea mariana	Black spruce	Widespread throughout	No	Yes	Hardy, shade, acid and cold soil tolerant, wildlife habitat
Populus deltoides	Western cottonwood	River floodplains in grassland	Yes	Yes	Flood tolerant, fast growing, wildlife habitat
Hybrid P. deltoides	Brooks poplar	————	Yes	Yes	Hardy, drought tolerant, fast growing, ornamental value
Hybrid P. deltoides	Walker poplar	————	Yes	Yes	Hardy, fast growing, ornamental value
Picea engelmannii	Engelman spruce	Subalpine	Yes	Yes	Hardy, shade and cold soil tolerant, wildlife habitat, ornamental value
Pseudosuga menziesii	Douglas fir	Montane	Yes	Yes	Chinook and drought tolerant, wildlife habitat and ornamental value

Reclamation Research Reports

1. **RRTAC 79-2: Proceedings: Workshop on Native Shrubs in Reclamation. P.F. Ziemkiewicz, C.A. Dermott and H.P. Sims (Editors). 104 pp. No longer available.**

The Workshop was organized as the first step in developing a Native Shrub reclamation research program. The Workshop provided a forum for the exchange of information and experiences on three topics: propagation; outplanting; and, species selection. Seven papers and the results of three discussion groups are presented.

2. **RRTAC 80-1: Test Plot Establishment: Native Grasses for Reclamation. R.S. Sadasivaiah and J. Weijer. 19 pp. No longer available.**

The report details the species used at three test plots in Alberta's Eastern Slopes (one at Caw Creek Ridge and two at Cadomin). Site preparation, experimental design, and planting method are also described.

3. **RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp. $10.00**

This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

4. **RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier (Editors). 160 pp. $10.00**

Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

5. **RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker and D.F. Polster. 2 vols, 541 pp. No longer available.**

Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their suitability for use in reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

6. **RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp. $10.00**

This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

7. **RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stein, R. Leitch and G. Lutwick (Editors). 253 pp. $10.00**

Presents nine technical papers on the chemical, physical, and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites, and use of ash as a soil amendment. Workshop discussions and summaries are also included.

8. **RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp. $10.00**

Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system (in a SPIRES database called RECLAIM). Vol. 2 comprises the keyword index and computer access manual.

9. **RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp. $5.00**

This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available in the Alberta Environment Library.

10. **RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp. No longer available**

Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

11. **RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp. No longer available.**

Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

12. **RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz (Editor). 123 pp. $10.00**

Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics, and resulting water quality. Mitigative measures and priorities were also discussed.

13. **RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp. No longer available.**

This is a review and analysis of information on planting stock quality, rearing techniques, site preparation, planting, and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

14. **RRTAC 84-1: Land Surface Reclamation: A Review of the International Literature. H.P. Sims, C.B. Powter and J.A. Campbell. 2 vols, 1549 pp. $20.00**

Nearly all topics of interest to reclamationists including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

15. **RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp. $10.00**

This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

16. **RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

17. **RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 2 vols, 676 pp. $10.00**

This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

18. **RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz (Editor). 416 pp. $10.00**

Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

19. **RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

20. **RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp. $10.00**

The report examines the critical issue of settling pond design, and sizing and alternative technologies. The study was co-funded with The Coal Association of Canada.

21. **RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp. $10.00**

Reconstructed soils representing different materials handling and replacement techniques were characterized, and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

22. **RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp. $5.00**

In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

23. **RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp. $10.00**

This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

24. **RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 71 pp. $10.00**

This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

25. **RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp. $5.00**

The report deals with the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is in the Battle River Mining area in east-central Alberta.

26. **RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp. $5.00**

This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

27. **RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

28. **RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp. $10.00**

This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed. The study was co-funded with The Coal Association of Canada.

29. **RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp. No longer available.**

Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

30. **RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp. $10.00**

This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area. The study was co-funded with The Coal Association of Canada.

31. **RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (Compiler). 218 pp. $10.00**

Technical papers were presented which describe: mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

32. **RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

33. **RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp. $10.00**

The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the East Slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed. The study was co-funded with The Coal Association of Canada.

34. **RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp. $10.00**

The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions. The study was co-funded with The Coal Association of Canada.

35. **RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp. No longer available.**

The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

36. **RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp. $5.00**

This report describes a study to evaluate the potential influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

37. **RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp. No longer available.**

This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

38. **RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus 8 maps. $10.00**

The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. Eight maps supplement the report.

39. **RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp. $10.00**

The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

40. **RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp. $10.00**

This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

41. **RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp. $5.00**

This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

42. **RRTAC 88-1: A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix. $10.00**

The report focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers. The study was co-funded with The Coal Association of Canada.

43. **RRTAC 88-2: Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (Compiler). 135 pp. $10.00**

Two reports comprise this volume. The first "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

44. **RRTAC 88-3: Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N_2-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp. $10.00**

The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and, (4) To conduct a field trial on reconstructed soil on the Syncrude Canada Limited oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their uninoculated counterparts.

45. **RRTAC 88-4: Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp. $10.00**

This three part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta," describes a series of laboratory tests to determine the behaviour of overburden materials when brought into contact with water. The report entitled "Classification System for Transitional Materials: Plains Region of Alberta," describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

46. **RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques and Outplanting Trials on Oil Sand Tailings. R.M. Danielson and S. Visser. 177 pp. $10.00**

The overall objective of this research was to characterize the mycorrhizal status of Jack Pine and Green Alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

47. **RRTAC 88-6: Reclamation Research Annual Report - 1987. Reclamation Research Technical Advisory Committee. 67 pp. No longer available.**

This annual report describes the expenditure of $500,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

48. **RRTAC 88-7: Baseline Growth Performance Levels and Assessment Procedure for Commercial Tree Species in Alberta's Mountains and Foothills. W.R. Dempster and Associates Ltd. 66 pp. $5.00**

Data on juvenile height development of lodgepole pine and white spruce from cut-over or burned sites in the Eastern Slopes of Alberta were used to define reasonable expectations of early growth performance as a basis for evaluating the success of reforestation following coal mining. Equations were developed predicting total seedling height and current annual height increment as a function of age and elevation. Procedures are described for applying the equations, with further adjustments for drainage class and aspect, to develop local growth performance against these expectations. The study was co-funded with The Coal Association of Canada.

49. **RRTAC 88-8: Alberta Forest Service Watershed Management Field and Laboratory Methods. A.M.K. Nip and R.A. Hursey. 4 Sections, various pagings. $10.00**

Disturbances such as coal mines in the Eastern Slopes of Alberta have the potential for affecting watershed quality during and following mining. The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin. There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

50. **RRTAC 88-9: Computer Analysis of the Factors Influencing Groundwater Flow and Mass Transport in a System Disturbed by Strip Mining. F.W. Schwartz and A.S. Crowe. 78 pp. $10.00**

Work presented in this report demonstrates how a groundwater flow model can be used to study a variety of mining-related problems such as declining water levels in areas around the mine as a result of dewatering, and the development of high water tables in spoil once resaturation is complete. This report investigates the role of various hydrogeological parameters that influence the magnitude, timing, and extent of water level changes during and following mining at the regional scale. The modelling approach described here represents a major advance on existing work.

51. **RRTAC 88-10: Review of Literature Related to Clay Liners for Sump Disposal of Drilling Wastes. D.R. Pauls, S.R. Moran and T. Macyk. 61 pp. $5.00**

The report reviews and analyses the effectiveness of geological containment of drilling waste in sumps. Of particular importance was the determination of changes in properties of clay materials as a result of contact with highly saline brines containing various organic chemicals.

52. **RRTAC 88-11: Highvale Soil Reconstruction Project: Five Year Summary. D.N. Graveland, T.A. Oddie, A.E. Osborne and L.A. Panek. 104 pp. $10.00**

This report provides details of a five year study to determine a suitable thickness of subsoil to replace over minespoil in the Highvale plains coal mine area to ensure return of agricultural capability. The study also examined the effect of slope and aspect on agricultural capability. This study was funded and managed with industry assistance.

53. **RRTAC 88-12: A Review of the International Literature on Mine Spoil Subsidence. J.D. Scott, G. Zinter, D.R. Pauls and M.B. Dusseault. 36 pp. $10.00**

The report reviews available engineering literature relative to subsidence of reclaimed mine spoil. The report covers methods for site investigation, field monitoring programs and lab programs, mechanisms of settlement, and remedial measures.

54. **RRTAC 89-1: Reclamation Research Annual Report - 1988. 74 pp. $5.00**

This annual report describes the expenditure of $280,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

55. **RRTAC 89-2: Proceedings of the Conference: Reclamation, A Global Perspective. D.G. Walker, C.B. Powter and M.W. Pole (Compilers). 2 Vols., 854 pp. $10.00**

Over 250 delegates from all over the world attended this conference held in Calgary in August, 1989. The proceedings contains over 85 peer-reviewed papers under the following headings: A Global Perspective; Northern and High Altitude Reclamation; Fish & Wildlife and Rangeland Reclamation; Water; Herbaceous Revegetation; Woody Plant Revegetation and Succession; Industrial and Urban Sites; Problems and Solutions; Sodic and Saline Materials; Soils and Overburden; Acid Generating Materials; and, Mine Tailings.

56. **RRTAC 89-3: Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soil. M.P. Sharma. 38 pp. $5.00**

Bromacil and Tebuthiuron were commonly used soil sterilants on well sites, battery sites and other industrial sites in Alberta where total vegetation control was desired. Activated charcoal was found to be effective in binding the sterilants in greenhouse trials. The influence of factors such as herbicide:charcoal concentration ratio, soil texture, organic matter content, soil moisture, and the time interval between charcoal incorporation and plant establishment were evaluated in the greenhouse.